LEARNING DESIGN FOR THE CLASSROOMS OF NEPAL:

A CONSTRUCTIVIST APPROACH TO LEARNING SCIENCE

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DEDICATION

This dissertation is dedicated to my beloved father in law late Mr Arun Prakash Mishra in honor of his guidance that enlighten me to get this result into fruition. His moral guidance always empowers me in the journey of education.

ABSTRACT

Academicians and practitioners have been addressing the theories of learning and instruction with the aim of understanding learning. Increased understanding of learning should, in turn, enhance the capability to design instruction and lead to more effective learning process. Social debates in education demands understanding of the complex learning needs of socio-cultural and linguistically diverse learners in Nepal today. There is, therefore, a need for analysis of the current thinking in cognitive learning and learning design theories from the perspective of constructivism. The exploration of effective practice to facilitate the task of designing learning environments seemed vital in this context. It was felt relevant to learn more about the implication of constructivism in different dimensions of pedagogic processes with reference to Nepal.

This study analyzed the constructivist perspective on learning delivery systems, learning style preference, and learning environments within a framework. This analysis was employed in the development of a secondary level school science studies premised upon the ideology that students employ intellectual tools at different stages of maturation for understanding specific subject knowledge. The resulting learning design for students contains the fundamental elements of constructivism, how these elements manifest themselves in a curriculum, appropriate learning strategies, and methods for evaluation. The research attempted contributing to inquiry into learning theory by an in-depth study of the elements of the framework itself, investigating how they function in different contents and contexts.

The statement of the problem was stated as – How Can a Framework of Learning be Designed and Developed that Accommodates Learning Style Principles, Constructivist Perspectives on Learning, and Instructional Design Principles? Following an extensive literature survey, the researcher synthesized an integrated framework of learning theories and instructional design practice from the cognitive family. Using qualitative study, supported by quantitative approach, mixed methods were undertaken applying the elements of the framework as an inquiry tool to determine what they reveal about the practice of effective and motivational learning. The framework of data analysis was based on Expert Science Teaching Educational Evaluation Model (ESTEEM), Kolb's Learning Style Inventories (KLSI) and sheltered instructional protocols. Information from the evaluations of the learning events was then used to further examine in-depth the theories that may differ in context and content, distinguishing particularly between well-structured and ill-structured domains.

The study attempted to synthesize a model with interplay of constructivism, learning style principles and the recent practices of learning design. The main achievement of the research study was to contribute towards generation of new knowledge for further modification of constructivist learning design principles with reference to Nepalese perspective. During the study, the constructivist-based teaching strategies were being used in the secondary level science classrooms, and constructivist teaching was evidenced that helped secondary level students understand science. The learning style preferences were found polarized in converging category and the balanced scheme was felt needed. The learning styles within the sub styles were recognized in the classroom. Learning strategies developed on the basis of learning style preferences enhanced the students' ability to learn science more effectively. The learning design was found learner friendly and appreciated by the learners. The findings suggested that learning through concrete experience engaged students in learning the content and enriched student's knowledge through theoretical models. The research has also explored the significance and implications of the present study to assess the existing theories for designing learning strategies. The study concluded in a discussion concerning the implications of coupling constructivist theory with the strengths of science learning, and the impact this union has on curriculum design, learning design/ facilitation, classroom management, assessment of learning, and policy formulation.

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Roj Nath Pande

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ABBREVIATIONS

ADDIE	Analysis, Design, Development, Implementation and Evaluation
BIG	Beyond the Information Given
CAI	Computer Assisted Instruction
CAL	Computer Assisted Learning
CBS	Central Bureau of Statistics
CDT	Component Display Theory
CID	Constructivist Instructional Design
CLD	Constructivist Learning Design
CLEs	Constructivist Learning Environments
CREATE	Centre for Research on Educational Accountability and Teacher Evaluation
CS	Community School
DLE	District Level Examination
ESTEEM	Expert Science Teaching Educational Evaluation Model
FGD	Focus Group Discussion
GoN	Government of Nepal
ID	Instructional Design
ICT	Information, Communication and Technology
IS	Institutional School
ISD	Instructional Systems Design
KELM	Kolb's Experiential Learning Model
KLSI	Kolb's Learning Style Inventory
KU	Kathmandu University

KUSOED	Kathmandu University School of Education
MOE	Ministry of Education
M Phil	Master of Philosophy
NGO	Nongovernmental Organization
OELEs	Open Ended Learning Environments
OLE	Open Learning Environment
PBL	Problem Based Learning
PBLE	Project Based Learning Environment
SIOP	Sheltered Instructional Observational Protocol
SLC	School Leaving Certificate
SOS	Save Our Soul
SPSS	Statistical Package for Social Science
TBIPE	Technology Based Interactive Practice Environment
TS	Trust School
WIG	With-out the Information Given

CHAPTER I

INTRODUCTION

In education, people face important decisions regarding the education of their children that affect their lives. The members of diverse groups evaluate these decisions in different ways. These issues are filtered through the screens of divergent experiences, group histories, educational problems, and present situations (Thomas et.al, 2005). So far Nepalese context is considered, the nation is undergoing social, political, economic and cultural changes. Such progressive changes demand improvement in instructional design and delivery approaches. Similarly, advances in technology have also dramatically changed the learning and teaching process and have provided new learning opportunities and access to educational resources beyond those traditionally available (Seimers, 2007). The debates over which direction the society should go in education are not likely to be meaningful or even mutually intelligible without some understanding of the complex learning needs of socio-culturally and linguistically diverse learners in Nepal today. Can the present educational system successfully meet the growing needs of socio-culturally and linguistically diverse students? Because of traditional teacher centered approach, students may not understand what the teacher is trying to convey to them.

On the other hand, according to Shih et al. (1998), identifying learners' learning styles help educators to understand how information is perceived and processed in different ways. A key to motivating learners to become involved in the learning process lies in understanding and using learning style preferences which can positively or negatively influence a learner's performance (Blackmore, 1996).

Edyburn (1997) observed that technology integration involves the purposeful selection and implementation of technology tools for the single purpose of enhancing instruction.

This brings to mind an enduring question of educational research: To what extent do individual differences affect the efficacy of learning? These individual differences present a profound challenge to learning designers. Research has shown that the quality of learning materials can be enhanced if the material is designed taking learners' individual learning styles into account (Riding & Grimley, 1999). It is also believed that adjusting teaching materials to meet the needs a variety of learning styles benefits all students (Agogino & Hsi, 1995).

Draude and Brace (1999) confirmed that there is substantial increase of using instructional technology in school education over the past few years. Computer technology provides educators and learners with lots of opportunities to transform the teaching and learning process by the adoption of a wide range of features, from the most common and simple uses to the most sophisticated. Advances in technology have also dramatically changed the learning and teaching process and provided new learning opportunities and access to educational resources beyond those traditionally available in Nepal. Nepal Government is currently looking at the reform in education through the use of information and communication technology (ICT) specifically with regard to the role of collaboration between the public, the private and donor sectors (OLPC, 2006). In this regard, Shrestha (2007) observed the following:

> The introduction of ICT in Nepal, particularly in the educational institutions, has created new possibilities for learners and teachers to engage in new ways of information selection, gathering, storing and analysis (pp.167).

In order to integrate and take optimal advantage of ICT capabilities, educational institutions need to solve a number of problems. The lack of theoretical frameworks in the development and implementation of a particular tool or approach (Milheim & Martin, 1991) and learning packages produced without pedagogical foundation (Greening, 1998) or sound instructional design principles (Siragusa, 2000) are examples of such problems. Additionally, Stones (2004) sounds a warning that if educators lack training in learning about and learning with modern technology, these become white elephants. Nobody has the skills or confidence to use them.

Science content alone can create significant barriers for all students and they may not understand what the teacher is trying to convey to them. Adding a language barrier to that in an English medium classroom, the students may have a difficult time interpreting what the teacher is teaching. However, it might be possible to help students understand science in English language by providing constructivist-based instruction (Paparozzi, 1998). Therefore, this study attempted to investigate the impact of constructivist teaching on students' ability to understand science in English medium science classrooms. Constructivist-based teaching might prepare teachers to help students understand science.

Focus of the Study

Many researchers in science education, educational psychology, and instructional technology accept constructivism as description of human cognition often associated with pedagogic approaches that promote active learning by doing (Santrok, 2001). In this approach guided by the teacher, students construct their knowledge actively through engagement in the learning process rather than just unconsciously ingesting knowledge from the teacher or from the textbook. The major areas to be focused are content covered, process under which students think and learn, and learning strategies used by teachers (Mestre, 1991).

Constructivist researchers (Santrok, 2001) have claimed that information and technology could facilitate in implementing constructivist learning approaches. Constructivist teachers pose questions and problems, and then guide students to help them find their own answers. They use many techniques in the teaching learning process. They may prompt students to formulate their own questions (inquiry), allow multiple interpretations and expressions of learning (multiple intelligences), and encourage group work and the use of peers as resources (collaborative learning). Constructivist approach borrows from many other learning practices such as behaviorist approach, cognitivist approach, etc. in the pursuit of its primary goal: helping students learn how to learn.

At the secondary level, science teachers have integrated classrooms, and the teacher must develop teaching strategies to help all students understand science. Neither all students have language barriers, nor every student struggles with science curriculum nor are students with empty vessels. In order to find that connection between learners and learning activities, a teacher needs to incorporate a style of learning preferences that relates to each and every student in the classroom.

Mestre (1991) argues science education in school needs restructuring. The issues that must be addressed are complicated. Basic or short-term solutions are not likely to succeed because teachers must upgrade their science knowledge in three important content areas: science content, how students think and learn, and learning strategies. All three areas should be addressed together (Mestre, 1991). As the size of student population increases, there are varieties of ways teachers can meet the educational needs in English medium science classrooms. Instruction should provide students the opportunity to interact with other students, interact with the content, learn to understand the viewpoint of others, think critically, test and question ideas, and form their own points of views (Miramontes, 1997). Constructivist-based teaching encourages these instructional approaches. Every child interprets content in a different way. They may have special needs, language barriers, social distractions and issues inside and outside the school. Each student, therefore, needs the opportunity to construct his or her own ideas.

Many different perspectives exist on constructivist pedagogical principles and on how to apply them to learning design. It is thus not only difficult to evaluate the conformity of existing learning systems with constructivist principles but also quite hard to ensure that a new learning system being designed ultimately facilitate and stimulate constructivist learning. The researcher was interested to pursue the models developed on the basis of constructivism describing how people learn, and how to design the constructivist learning environments with special reference to science education.

The Research Problems

Academicians and practitioners are addressing the theories of learning and instruction with the aim of understanding learning. Increased understanding of learning should, in turn, enhance the capability to design instruction and lead to more effective instructional practice. An extensive body of literature exists on theories of learning and the design of instructional resources and learning environments. Modern technology and self learning materials have not yet been integrated with the design and development of the science curriculum for secondary level students. The learning styles have been neither identified nor accommodated within the framework of instructional design based on constructivist learning perspective. There is, therefore, a need for the analysis of the current thinking in cognitive learning theory, learning style preferences and learning design theory from the perspective of constructivism to facilitate the task of

a. identifying learning style preferences and the learning resource preferences,
b. designing instruction and learning environments for learning science,
c. investigating existing systems from the viewpoint of constructivism, and
d. learning more about the implication of constructivism in different dimensions of pedagogic processes with reference to Nepal.

The statement of the problem was devised to govern the total research study. The statement was stated as – how can a concise framework of learning be designed and developed that accommodates learning style principles, constructivist perspectives on learning, and learning design principles?

Objectives of the Study

The prime objective of the study was to analyze the current thinking of constructivist perspective of learning theory, learning style principles, learning design theory and practice, so as to

a. explore existing environments, operational modalities, learning products and events of current classroom learning designs,
b. suggest classroom learning design framework relevant to the present context of the learning systems in Nepal, and
c. derive the implications of constructivist learning approach to educational setting.

Research Questions

Learning styles of the students have been neither identified nor accommodated within the framework of learning design based on constructivism as a learning perspective.

Within this context, the following research questions guided the inquiry:

1. How is the constructivist learning theories and the instructional design principles incorporated in classroom instruction of Nepalese schools?

In the context of an extensive literature survey of learning theories, approaches and models for the design and practice of learning, the following were investigated:

   a. What attributes consist in the current learning theories and learning design?
   b. How has the current learning design practices been put into operation?
   c. What evidences are there that the current learning designs include constructivist approach?

2. What experiential learning style preferences are prevalent in current classroom learning environments that correspond to learning design?

Based on learning style principles to comprise the experiential learning style preferences, in what ways and to what extent, are they found to be perceived and manifested in learning events that is, how has learning style preference been perceived by teachers and students for learning and instructional design?

3. In the current context, what framework of learning design would be relevant in the classroom instructional systems of Nepal?

Having selected theoretical and practical elements to comprise the framework of learning design as a tool, how does the learning and instruction reveal about the elements of the framework?

That is

a. What relationships occur in between the constructivist principles, learning design and experiential learning style principles that account for a framework?
b. What are the implications of constructivist approach in formulating educational policies, curriculum development, classroom instruction, teacher training and learning assessment systems?

Significance of the Study

The large body of literature on current learning and instructional theories from the cognitive family can be overwhelming to designers and practitioners of instruction. The framework of learning design that has been generated in this study, suggest an interrelated set of cognitive learning theories and learning design approaches to serve as an aid in the design, development and investigation of learning events and environments.

Little evidence has been found in the literature about the impact of different learning styles and constructivist learning principles on the design of technology backed process of learning. The first contribution of this research study is in that regard. Secondly, the study seeks to make a contribution to the field of science education, in the design and development of technology based learning materials, and the assessment and evaluation of those learning materials.

This study supports designers and practitioners in the field of facilitating effective learning. It contributes to an understanding the constructivist perspective of learning and instructional theories, and inform practice on their relationship to the design, development and delivery of instructions and learning environments. The set of criteria and framework for learning design can be used to devise and evaluate learning conditions easily in different instructional situations like traditional instruction, technology based instruction, and open learning. It can be reused for the other facets of constructivism.

This study has explored the field to select, integrate, and extend knowledge on constructivist perspective of learning theories. It helps to obtain further knowledge about constructivist perspective of learning theories and characteristics in practice. The ultimate significance is thus to help designing constructivist and adaptive learning environment for similar contexts within the broader Nepalese context.

Scopes/ Limitations of the Study

Before the development of this study, the researcher had set out the researcher's various limitations on the field. They included -

a. the view in this study of learning design and learning systems which were based on constructivist perspective,
b. the domain of the study and its literature resources that were related particularly to current learning theories and approaches to the design of instruction, as well as contemporary learning practices,
c. the view of learning style preference focusing on experiential learning which is based on Kolb's Learning Style Inventory (KLSI),
d. the view of technology which were limited to computer technology, computers in their roles as presentation and practice tools, communication and productivity tools. Other technologies like television, video, radio, satellite, and cellular/digital telephones were excluded, and

Delimitations of the Study

The study primarily represents the thinking of the past 17 years, in particular, resources that published since the major debate on constructivism commenced in

1991. Behaviorist tendencies dominated instruction till the influence of cognitive psychology in the 1980s, and this in turn was followed by the advent of constructivism. The realm of current thinking in cognitive-based learning theory, learning design theory, and effective practice was a broad and inter-related field, which the researcher had to delimit, since it was difficult to cover all relevant sources. Within the cognitive family, the researcher positioned constructivism at one extreme as an experiential form of the cognitive science and pragmatic instructionism at the other. The literature survey was delimited to a selection of classical works on the various instructional paradigms and philosophies of learning. The main context of literature was instruction and learning that use technology and locally available resources.

Operational Definitions of the Key Terms

The terms used in this report are generally accepted, traditional meanings in the domain of instruction and instructional design. These terms set the background for this study and form the context out of which the newer approaches like constructivist learning environments exist.

Instructional Design Theory: it is design oriented focusing on how to attain goals for learning rather than description oriented focusing on the effects of given events. It identifies methods of instruction - the ways to support and facilitate human learning and development, and situations in which those methods should and should not be used.

Learning Theory: It describes how learning occurs but do not identify or prescribe methods for promoting learning. By contrast, instructional design theories are applied in practice and are theories that identify methods for use in practical situations as well as comprise methods and situations and also relates to events external to learners rather than describing what takes place within learners when learning occurs.

Learning Design: It comprises prescriptive instructional design theories and models which set out methods for developing instruction, along with the conditions under which each should be used to produce a desired learning outcome. It is a technology for the development of learning experiences and environments which promote the acquisition of specific knowledge and skill by student. The classical model of design and development of instruction incorporates evaluation – both formative evaluation within workplace and summative evaluation on the final product.

Learning Design Process: It is what a teacher or designer does to plan and prepare for the instruction, also called learning systems development. Learning Systems Development is a set of procedures for systematically designing and developing learning materials learning systems development process to represent the actual process and procedures of designing instruction which are closely related to underlying theories.

Instruction: It involves guiding students to appropriate learning activities, helping them to construct appropriate knowledge, encode, and process information, monitoring student performance, providing feedback to their learning activities and practice. It is an organized set of methods, materials, and assessments designed to promote competence in defined outcomes (Dick, 1991).

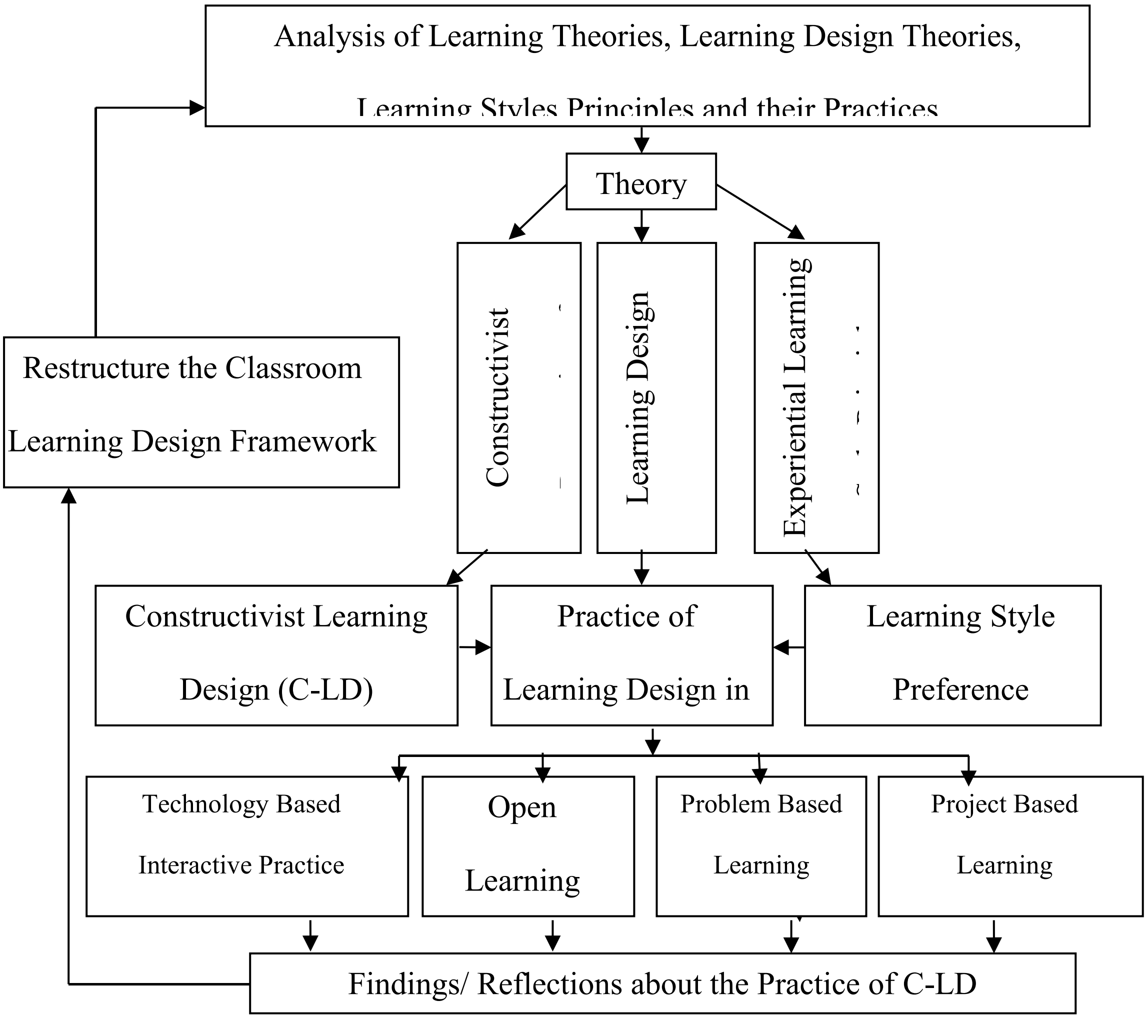
Learning Events: The learning events considered in this research are technology based practice environment, open learning environment, problem based learning and a field work project which are based on researcher's close involvement with each intervention.

Conceptual Framework

The compacted and integrated framework of learning design and learning theory generated in this study is not the prescription. It is a framework suggesting an interrelated set of constructivist learning theories, learning style principles, and instructional design approaches to serve as an aid in the design, development and investigation of learning events and environments. The integrated framework comprises synthesis of theoretical concepts of constructivism, learning style and learning design in current learning system followed by constructivist learning design intervention within the experiential learning style preferences. The figure presented below illustrates the conceptual framework of the present study.

The framework consists of the three major components of the research strategy. The first component explains about the analysis of the learning theories, instructional design theories and learning style principles. The second component of the conceptual frame incorporated the existing practice of learning design, constructivist learning design and learning style preferences. The third component of the research frame analyzed the practice of learning design in classrooms of Nepalese schools including Technology Based Interactive Practice Environment (TBIPE), Open Learning Environment (OLE), Problem Based Learning (PBL) and Project Based Learning Environment (PBLE). Figure 1.1 illustrates the composite framework of the research study including reflection/ findings for the restructuring of the Classroom Learning Design.

Figure 1.1: Conceptual Framework of the Study



The reflections and findings about the practice of constructivist learning after the intervention of TBIPE, OLE, PBL and PBLE would assist to restructure the classroom learning design framework.

Organization of Report

The thesis report has been developed in seven chapters. The first chapter deals with the introduction of the thematic study. The second chapter concerns with literature study including learning and instructional theory, and instructional systems design in practice. This section also explains synthesis of instructional theories and systems from the perspective of constructivism. The research methodology has been mentioned in the third chapter including study milieu selection, information collection techniques, design experimentation and instrumentation. The fourth chapter deals with the physical setting of the research milieu, the data analysis and the findings on the basis of study results describing how the secondary level learner learn science. Similarly the chapter five describes the learning styles of the learners perceiving learning design and constructing knowledge. Chapter six focuses on the discussion of the findings deriving the congruencies within learning design framework. The final chapter seven presents summary, conclusion, and implication on the basis of the study results. Table 1.1 provides the precise summary of the organization of the study report.

Table 1.1

Organization of the Research Report

Chapters	Key Components
I	Brief introduction of thematic study of the research
II	Extensive literature surveys including Section I: Theoretical perspectives on Learning and Instruction, Section II: Learning focused paradigm of instructional theory, Section III: Constructivist epistemology of science education, Section IV: Learning Styles Section V: Evidences from the contemporary related research studies Section VI: Synthesis towards an integrated theoretical framework
III	Research Methodology including study milieu selection, methods of information collection, techniques of data analysis and validation
IV	How Secondary Level Learners Learn Science
V	Learning from own styles: Perceiving learning design and constructing knowledge
VI	The Congruencies within learning design framework
VII	Summary, New Grounded Settings, Contribution of the Research, and Implications on the basis of the study results

Chapter Summary

The main purpose of this chapter was to build up a case of Nepal to show the significance of the present study to assess the guidelines and frameworks of the instructional design from the perspective of constructivism of cognitive domain of learning. A statement of the problem was devised to facilitate the research study. The statement of the problem was diffused into a set of three major research questions for the detailed analysis of learning design based on constructivism. Significance, assumptions, limitations and delimitations of the study were presented before the presentation of the operational definitions of key terms and the organization of the study.

The next chapter presents the selected literature review related to the principles and practices of learning design and learning theories from the perspective of constructivism and experiential learning style principles.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The basic purpose behind the literature review, in this chapter, was to supplement the scholars existing level of knowledge about learning and instructional theories with special focus on constructivist paradigm. The review also supported in designing the theoretical framework for the study.

To accomplish the above stated purpose, this chapter has six distinct sections. The first section presents with the reviews of various literatures from the theoretical perspectives related to learning and instruction with special focus on constructivist epistemology. Selected literature from the related studies has been reviewed in the second section of the chapter focusing on Learning focused paradigm of instructional theory. The third section dealt with the constructivist epistemology concerning science education. This section has also incorporated overlaps in constructivism and best practices for the science learners. The fourth section dealt with the review on experiential learning style preferences of the learners. Evidences from contemporary related research studies were reviewed and incorporated in the fifth section. The sixth section presents the theoretical framework of the study designed on the basis of the theoretical knowledge gained through review of literature in the previous sections.

Theoretical Perspectives on Learning and Instruction

The perspectives overviewed and discussed in this section fall into three main theoretical categories – the behaviorist, cognitivist, and constructivist theories of learning. Each of them is overviewed under various headings, setting out its background, key characteristics, and examples of related perspectives.

The Behaviorist Perspective

For the first half of the twentieth century, behavioral theories provided the foundation for the most conceptions of learning. Behaviorists emphasized overt behavior rather than covert mental operations, and learning was understood as a change in the behavioral dispositions of an organism. As behaviorism was increasingly implemented in educational practice, learning materials were explicitly designed in this regard. Systematic design procedures in the learning arena became inherently behaviorist. As Barden (1996) mentioned, these procedures derived effective, efficient and relevant instruction by designing objectives, content, instructional methods and learner-assessment procedures in congruence with one another. These traditional practices of instructional design were characterized by Skinnerian psychology, and were especially manifested in programmed instruction (Dick, 1995). Detailed work on instructional objectives and goals was undertaken by Gagne (1985). He made the assumption that based on different kinds of instructional goals, different instructional strategies are required for learners to attain given kinds of learning effectively and efficiently. Gagne proposed a descriptive theory of knowledge defining five categories of learning outcomes each of which requires different instructional treatments and different conditions of learning for the outcome to occur (Gagne & Glaser, 1987). The categories of learning outcomes include verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes.

Behaviorist learning theory suggested that learning outcomes are demonstrated by observable and measurable behavior. Instructional interventions, accompanied by selective reinforcement, are used to shape such learning behaviors. Skinner (1938), a classical protagonist of this theory, was reluctant to address the role of internal cognitive or conceptual activity as a part of learning process. Behaviorist learning is managed by stimuli from the environment, which result in responses from the learner. The stimulus-response pattern of behavior is manifested in the learner's overt reactions (Venezky & Osin, 1991). Correct responses are rewarded with immediate reinforcement, leading to a stimulus-response-reinforcement paradigm. The theory originally developed from experiments with animals, later applied to human learning by examining the effect of instructional intervention. It assumes frequent re-presentation, usually in increasing levels of difficulty. The behavior of an organism is viewed as a function of external stimuli and learning is viewed as the construction of a set of stimulus – response associations, induced by repetition and reinforcement. It avoids addressing internal cognitive processes, dealing rather with measurable behavior and skills. This contrasts with the cognitive perspective where learning is viewed as the processing of information and storage within long term memory.

Behaviorist instruction is generally accepted to be in line with objectivism. Objectivist epistemology defines knowledge that is separate from knowing (Reeves, 1997). According to Reeves (1997) from the view point of objectivism, reliable and stable knowledge exists about the world and concepts within it. The knowledge and skills which educators require their learners to know and be able to do can be correctly structured and specified. The effective and efficient means can be determined to instill such knowledge and skills into learners. The truth of beliefs is testable by reference to the facts (Jonassen, 1991). In empiricist and post empiricist philosophies, the term objective refers to statements that can be empirically shown to correspond with a reality external to individuals (Duffy, 1991). The educational technology is based on the assumption that objective knowledge is universal knowledge. Hence many instructional design processes call for detailed pre-set instructional objectives and criterion- referenced assessment in line with the objectives.

Instructionist foundations generally refer to well defined and explicit learning aims and methods. The knowledge and skill requirements can be articulated, progress can be evaluated, and mastery can be demonstrated. This type of system often reflects a reductionist approach – a bottom –up, with basics – first curriculum and teaching methods (Duffy, 1991). Under instructionism, learners tend to be passive recipients of instruction. Since instructionists are pragmatists who tend to reconcile theoretically ideal situations with those optimally suited to available resources and constraints, then need based information and skills training are presented. Instructionism occurs in learning systems that offer modular, internally consistent, discrete subjects. They are presented in fixed duration class periods of traditional schools. Epistemologically, it is associated with objectivist philosophy, and they are jointly termed as the objecitivist-instructionist approach (Reeves, 1997).

The behavioral approach epitomizes reductionism. Most sciences aim for reductionism – a simplification of their observations and explanations (Schoenfeld, 1993). This approach uses models to represent complex phenomena. Reductionist instructional models entail a linear approach that studies components of a domain independently, progressing from basics to more complex. It is rather than holistic approach that investigates overall relationships and complex interactions between component parts within the context.

Behaviorism emphasizes the design of instruction and the imparting of knowledge, with the goal of achieving effective and efficient learning. Learning, in this connection, is demonstrated by behavioral changes. The role of the instructor is paramount over the role of the learner. The learners tend to receive instruction in a passive manner. The processes are geared towards learners in general, and are not focused on individual learners. This approach may be appropriate for well-defined problems, but is ineffective in ill-structured domains. Traditional instructional design models are built on deterministic foundations (Rowland, 1995) and are largely behaviorist. It is assumed that an optimal instructional design can be procured by analyzing a situation thoroughly to identify its definitive conditions and desired outcomes, and then applying the principles, prescriptions, and strategies for those conditions. Despite the structured and systematic nature of behaviorism, its shortcomings and rigidity began to evidence themselves. As a result, the school of cognitive science emerged. Some of the initial reservations on the part of cognitive theorists were due to the fact that much of the behaviorist research was carried out on animals (Cook, 1993). Nevertheless, certain aspects of behaviorism are proven to facilitate specific types of learning, and these should be subsumed, not replaced, by the new methodologies. Schoenfeld (1983) urges against rejection of behaviorism, pointing out that the way it addresses human verbal behavior can play a meaningful role, and is not the same as the way it sets out to shape reflexes and responses. Many behaviorists of the humanist-cognitive persuasion view verbal behavior as a communicative channel, impacted by experience and thoughts. It is shaped by the individual's socio-cultural environment. Both behaviorists and non-behaviorists would agree on the importance of cultural background and social origins in influencing learning. There has been a revolution in learning theory since the late 1960s. The paradigm shift of psychology of learning has taken place from the behavioral approach to cognitive theories and models. It has focused on the mental processes involved in learning (Jonassen, 1991). The research concentrated on how and why learners learn as a result of which new theories of instruction and learning emerged.

The Cognitivist Perspective

From the psychologists' point of view, learning is concerned less with behavioral responses – what learners do – and more with what learners know and how they acquire knowledge. Cognitive theorists advocate for promoting aspects like the cognitive processes leading to higher order thinking among learners. The learners attain new knowledge and skills with the internal mental representations. They actively acquire information. Some earlier cognitive applications were developed in the field of artificial intelligence. During the 1980s, intensive research was undertaken in the realm of cognitive development applied to human learning. Theories of cognitive science view learning as the execution of internal cognitive processes like thinking, remembering, conceptualization, application, and problem solving. Learning entails a reorganization of the brain's knowledge structures (Duffy, 1991). In line with this approach, instruction is presented in ways that foster understanding and develop meta-cognitive skills within learners.

By the 1990s the behavioral approach was giving away to a cognitive paradigm. Particular attention was paid on fostering higher-order thinking skills within learners. Theorists posited that knowledge attainment is not from mastering a hierarchy of skills, but from the use of critical thinking skills and the comprehension of fundamental concepts (Jonassen, 1991). Benjamin Bloom developed a taxonomy that has been frequently used to categorize types of educational objectives for the cognitive domain. The taxonomy identifies six major types of learning, ordered from lowest to highest, of which the last three types call for cognitive skills: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. The transition from behaviorism to cognitivism spotlights the issue of instructional and learning goals. Gagne and Merill (1990) moved towards cognitivism by affirming the need for extension of these concepts to address situations. The instructional goal was considered as a combination of several different objectives. They accepted the effectiveness of working backward from a goal to the required instructional events. The term enterprise schema was used by them to refer the integration of multiple learning objectives for the enterprises. They perceived an enterprise schema as a cognitive representation, proposing that the integrated goals of various different enterprises are stored in human memory in terms of mental models. In the context of learning and instructional theory, the distinguishing feature of an enterprise is, therefore, the presence of integrated goals. It incorporates multiple objectives for a comprehensive holistic learning activity.

The early cognitive position was characterized by instructor- centricity, relying heavily on the terms: instruction and student. Viewing cognitive trends of the mid 1990s, Jonassen, Campbell and Davidson (1994) described how intelligence and cognitive activity are distributed between learners and their supporting environment. This was a distinct paradigm shift. The medium is the part of this learning context, which in turn is part of a larger social context. This is an advance on the unsupported cognitive processes depicted in the basic human information processing models of the 1970s up to the mid 1980s. Moreover, students are no longer viewed merely as knower who store and remember information, but as true learners. They are considered as independent thinkers who process information meaningfully and relate it to their prior knowledge (Chien Sing, 1999). The teacher becomes more of a facilitator, one who is on the learner’s side (Reigeluth, 1991). These philosophies go hand in hand with the emergence of true constructivist learning environments in the mid – 1990s. Constructivism, introduced and investigated in the following section has sometimes been termed as an implementation of cognitivism. Although it is related, it is far broader than this description would imply. It diversifies and occupies its own territory, both in terms of theory and the practice of learning.

The Cosmos of Constructivism

Constructivism originates from Bruner's theoretical framework for instruction (Bruner, 1994). The framework is based on the study of cognition. It postulates that learning is an active process in which learners construct new ideas or concepts based upon their past and current knowledge. Bruner taught mathematical concepts to children, providing them with materials to build, visualize, and measure physical patterns or constructions. Bruner suggested that instruction is not a matter of getting learners to commit results to mind rather it is to teach to participate in the process that makes possible the establishment of knowledge. Knowing is a process, not a product (Reigeluth, 1991). Reeves & Reeves (1997) illustrated that constructivism is a philosophy that emphasizes the development of cognitive structures by learners based on their knowledge and their experiences in learning environments. From one viewpoint, constructivism is positioned as an experiential form of the cognitive sciences. But in another view it is a separate paradigm from cognitivism due to the view of cognitive learning as an implementation of objectivity. Holders of the latter view stand as the antithesis of constructivism. Bednar et al (1992) hold the first opinion referring to the constructivist view of cognition. In this connection, Wilson (1999) termed constructivism as an elaborated version of cognitivism. Likewise, Greeno, Collins and Resnick's (1996) cognitivist/ rationalist view also incorporated some of the aspects of constructivist approach.

The concept of constructivism has roots in classical antiquity, going back to Socrates' dialogues with the followers. These dialogues, the directed questions, led the learners to realize for themselves the weaknesses in their thinking (Miramontes, 1997). According to the author, the Socratic dialogue is still an important tool in the way constructivist educators assess their students' learning and plan new learning experiences. He further added that instruction provides students the opportunity to interact with other students, interact with the content, learn to understand the viewpoint of others, think critically, test and question ideas, and form their own points of views. He claimed that constructivist teaching encourages these instructional approaches. Each student, therefore, needs the opportunity to construct his or her own ideas. Jean Piaget in this connection believed that humans learn through the construction of one logical structure after another. He also concluded that the logic of children and their modes of thinking are initially entirely different from those of adults. The implications of this theory and how he applied them have shaped the foundation of constructivist perspective in education (Brooks & Brooks, 1999). Similarly, Dewey called for education to be grounded in real experience. He expressed that if one has doubts about how learning happens, it is necessary to engage in sustained inquiry: studying, pondering, considering alternative possibilities and arriving at one's belief, grounded in evidence. Inquiry is a key part of constructivist learning (Vanderstraeten & Biesta, 1998).

Vygotsky on the other hand introduced the social aspect of learning in constructivism according to which students solve problems beyond their actual developmental level. They remain under adult guidance or in collaboration with more capable peers. In this connection, it is called dialectical constructivism (Gergen, 1995).

Bruner (1990) initiated curriculum change based on the notion that learning is an active social process in which students construct new ideas or concepts based on their current knowledge. Papert (1980) performed groundbreaking work in using computers to teach children and this led to the widespread use of computer and information technology in constructivist environments. Constructivism proposes that learning environments should support multiple interpretations of reality, knowledge construction, and context rich experience based activities (Jonassen, 1991). The different types of constructivism are conceived which are categorized as: Social constructivism, Radical constructivism and Cognitive constructivism (Doolittle, 2000). None of these types of constructivism should be seen as a set of methods. It is not a fixed manifesto like set of beliefs. They are “points of view” respectively, and are loosely defined by a collection of thoughts of particular individual writers in each case (Dougiamas, 1998).

Social (Dialectical) Constructivism

Among the three broad strands within the constructivist tradition, the first one is social constructivism. Many of the authors (Greene, Jensen, Jones, et al) who account for social constructivism traced their ideas back to Vygotsky, a pioneering theorist in psychology and philosophy. He focused on the roles that society plays in the development of an individual (Cobb, 1998). Similarly for Lyddon (1995), constructivism is the human mind that plays an active role in organizing and creating, literally investigating, rather than discovering the reality. Through social interaction, individuals co-construct different ways of categorizing reality. Individuals interpret, assign meaning, and create assumptions about themselves, other people, and their environment. These factors provide the foundation for their knowledge of the world (Greene et al, 1996). One’s cultural background is a critical factor in understanding the reality and co-constructing the meaning with others (Greene, Jensen &Jones, 1996). The truth is not to be found inside the head of an individual, it is born between or among people collectively searching for truth in the process of their dialogic interaction. The truth, in this case, is not taken as the objective reality of the radical constructivists, but rather is a socially constructed. It is agreed upon the truth resulting from “co-participation in cultural practices" (Doolittle, 2000). Constructivist epistemology proclaims that learners are assumed to be self-directed and able to take cultural leaps if supported by mediation and scaffolding (Henning & van der Westhuizen, 2003). The concept of the zone of proximal development, a Vygotskyan theory, believes that learning is directly related to social development. Good instruction could be provided in determining the level where each child is in his or her development, and building on that child’s pre-existing experiences. Vygotsky (1978) asserted that the zone of proximal development is the actual developmental level determined by independent problem solving exercise through adult guidance or through collaboration with more capable peers. His theory of development has been referred to as a cultural historical theory. Vygotsky was perhaps one of the first psychologists to suggest the mechanisms by which culture becomes part of each person’s nature. His developmental theory differs in significant ways from other theories of child development. Central to his theory was the understanding that all phenomenon be studied as processes in motion and change. Every phenomenon has its history and this history is characterized by qualitative and quantitative changes.

Vygotsky believed that our life experiences affect and influence our development and learning. The social context influences learning and shapes how and what we think. From his perspective everything about learning and development is social and hence the name social constructivism. The following four basic principles underlying Vygotskian theories guided the present study:

1. Development cannot be separated from its social context,
2. Language plays a central role in mental development,
3. Children construct knowledge, and
4. Learning can lead development (Vygotsky, 1978)

Vygtsky proposed that even when we are carrying out a mental action in isolation, we are not really participating in an individual mental process but are rather still operating in a social context. We are using the social and cultural tools of language when reading a book, even doing so alone. Books themselves are social, cultural and historical artefacts (Wink & Putney, 2001). For Vygotsky, the human mind is the product of both human history or phylogeny, and a person's individual history or ontogeny (Bodrova & Leong, 1996). He viewed learning and development as dialectical in nature. For him, cognitive construction is always socially mediated. The social context is part of the developmental and learning process.

Meanwhile, Dewey (1933) pointed out that we live from birth to death in a world of persons and things, the real work done by habits which is fixed habits as to be institutional. It is because of what has been done and transmitted from previous human activities. There are sources outside an individual which give rise to experience. According to Copley (1992), constructivism requires a teacher who acts as a facilitator. The main function of the teacher is to help learners become active participants in their learning and make the meaningful process. Omrod (1995) indicated that teachers could encourage learners' cognitive development by presenting tasks that they can complete only with assistance, that is, within each learner's zone of proximal development. Next, the zone of proximal development can be taken into account of a situation in which the learner can be provided with support for optimal learning. Another situation within the principle of social constructivism is applied in the classroom. The appropriate learning situations, in which one should take into consideration that learning takes place in a meaningful context, preferably the context in which the knowledge is to be applied. Lastly, out of classroom experiences, social constructivism supports the idea of using the related classroom experiences. Use of pictures and personal stories from the relevant context incorporated into classroom activities provide the learners with a sense of oneness between their community and learning. Social constructivism implies that knowledge is the result of social interaction and language usage, and thus is a shared, rather than an individual experience (Cottone, 2001).

Cognitive Constructivism

This is another category of constructivism based on the work of Piaget, whose theory of cognitive development states that humans construct their own knowledge through experience. Experiences enable them to create schemes that change, enlarge and are made more sophisticated through two complimentary processes: assimilation and accommodation (Wadsworth, 1989). Assimilation is the integration of external elements into the organism's existing structure, the filtering of the stimulus through an action structure so that the structures are themselves enriched. Accommodation is the adjustment of internal structures to the particular characteristics of specific situations. According to Ertmer and Newby (1993), cognitive constructivist theory states that knowledge construction is a mental activity that entails internal coding and structuring by the learner. Therefore, Learning, in this view, is individualized and personalized for each learner, taking into account the prior knowledge, the cultural background and the interests, as well as cognitive levels and skills. Piaget (1970) and Gredler (1997) explained two basic assumptions of cognitive constructivism:

a. a constructivist view of intelligence means that intelligence and knowledge are not static qualities or products. They are ever-changing processes, and

b. intelligence is an organized system that constantly interacts with the environment and actively constructs the structures needed to adapt to the environment.

Constructivism, as a cognitive position, leads to the adaptation of pedagogical constructivism (Noddings, 1990). From a cognitive constructivist position, the components of instruction should be characterized by the use of methods that support the spontaneous research of the learner. It also incorporates collaboration and interchange among learners (Gredler, 1997). Instruction in the classroom should provide learners with more opportunities for cognitive growth through exploration, unstructured learning, and problem solving (Roblyer, Edwards & Havriluk, 1997).

Radical Constructivism

Radical constructivism is another category in the concept of constructivism. According to Dubinsky (2000), radical constructivist theory is derived from cognitive-development theory and was coined by Von Glasersfeld (1990), who maintained that all knowledge is human construction and reality is not accessible to rational human knowledge. Furthermore, an individually constructed view cannot be judged on the basis of correctness. Dubinsky (2000) emphasized that there is no external reality, or at least a human being constructs reality for her or himself depending on the context in which they are. This notion of reality applies both to ideas in the mind and what we refer to as physical reality or the real world. According to Doolittle (2000), radical constructivism is knowledge which is constructed from individual experience. For Steffe and Thompson (2000), radical constructivism refers to processes involved in subjective cognitive construction known as assimilation, accommodation, and reflective abstraction (2000). On the other hand, Von Glasersfeld (1990) argued that coming to know is a process of dynamic adaptation towards viable interpretations of experience, in which the knower does not necessarily construct knowledge of a real world. He further elaborated that we construct our knowledge. Knowledge is not and cannot be placed inside our heads but rather we make our own knowledge by selectively using our experiences to create mental structures that form the basis of our knowledge. Radical constructivism does not deny an objective reality but simply states that we have no way of knowing what reality might be (Dougiamas, 1998). Riegler (2001) argued that the basic tenet of radical constructivism is that any kind of knowledge is constructed rather than perceived through the senses. Thus, from a radical constructivist perspective, communication need not involve identically shared meanings between participants. It is sufficient for their meanings to be compatible (Powers, 2001). Kock (1990) acknowledged that a radical constructivist's understanding of interaction is harmonious with the idea that individuals are all indispensably social individuals. Right from the moment of our conception, we are in company and from birth we begin to be socialized that is, adapted to the prefabricated world that is the consensual framework of everybody’s permanent participant realization of the society or group. Bodner, Klobuchar and Heylighen (1997) stated that Von Glasersfeld constructed his theory of radical constructivism on the following basic principles:

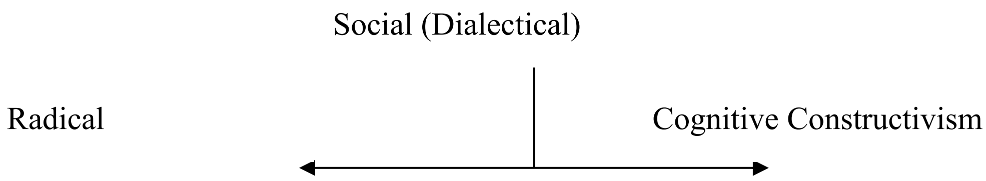
a. knowledge is not passively received, either through the senses or by way of communication, but is actively built up by cognizing subject,
b. the function of cognition is adaptive, and serves the subject’s organization of the experiential world, not discovery of an objective ontological reality,

c. radical constructivism is a model of rational knowing and therefore excludes metaphysical realism, or objective ontological reality (Watzlawick, 1991), and

d. knowing has roots in both biological/ neurological constructions, as well as in social, cultural, and language based interactions (Doolittle, 2000).

These four fundamental assumptions provide the foundation for basic principles of the teaching, learning, and knowing process as described by radical constructivism. Figure 2.1 illustrates the dimensions of constructivism not as a unitary theoretical position, but rather as continuum (Dougiamas, 1998) and as points of view (Doolittle, 2000).

Figure 2.1 Dimensions of the constructivist perspective on learning

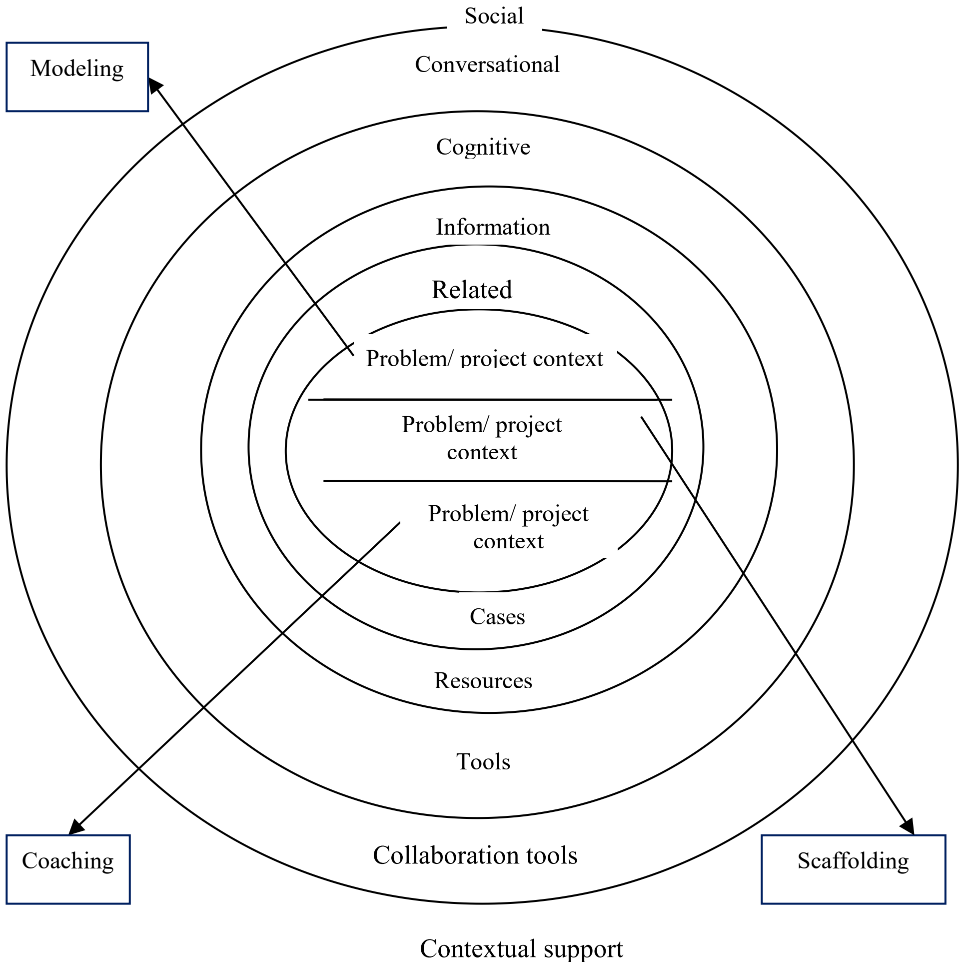


From these three broad categories of constructivism, social, radical and cognitive, the essential core is that learners, in social constructivism, actively construct their own knowledge and meaning from their experiences. There is emphasis on the construction of an agreed-upon, socially constructed reality, the radical constructivist approach create a coherent experiential reality, such as learning environment and the cognitive constructivist articulate mental constructions of reality in the learning process (Doolittle, 2000). In this connection, constructivist learning environment (CLE) could be a platform for constructing knowledge.

A constructivist learning environment is a place where learners may work together and support each other. They use variety of tools and information resources in their guided pursuit of learning goals and problem solving activities (Wilson, 1996). McLoughlin and Luca (2000) postulated that in a constructivist learning environment, there is interaction, communication, exchange of views, collaboration and support for learners that help them to become aware of and take responsibility for their own learning process. The salient features of a constructivist learning environments include an emphasis on features such as authenticity (learning located in actual contexts or real tasks), group work (the social interaction and feedback instrumental in communication and higher order thinking processes), learner control (learners active in defining and negotiating learning tasks), and scaffolding (support of learners as they progress from novice learners to self-regulated experts) (McLoughlin & Luca, 2000). A constructivist learning environment requires self-regulation and the building of conceptual structures through reflection and abstraction (Von Glasersfeld, 1996). For educators, the challenge is to be able to build a hypothetical model of the conceptual worlds of learners. These worlds could be very different from what is conceived by the educator. Additionally, new technologies have posed many challenges for educators. These technologies have great potential for achieving many of the underlying goals of education. However, like a tool, they must be used reflectively and viewed through a critical lens (Imel, 2001). The challenge is to use computer technology in a way that supports learning and responds to the needs of the learners.

An appropriate method is required for analyzing desired learning and designing CLEs. A CLE is based on an appropriate problem, question, or project with support from intellectual systems or tools. The goal of the learner is to interpret and solve the problem or complete the project (Jonassen, 1999). A well designed CLE (Jonassen, 1999) is illustrated in figure 2.2. CLEs are ideal means of implementing question–based, case- based, or project-based learning with the problem. The focus of the environment is surrounded by support systems such as related cases, informational resources, cognitive and collaboration tools, and social support. Although certain objectivist methods may be included in a CLE, the basic difference between CLEs and objectivist learning is that the problem drives the learning, rather than merely serving concepts and principles. In other words, students learn domain content in order to solve the problem, rather than solving the problem as an application of learning (Jonassen, 1999). The central issue or problem should be ill-structured, so that some of its aspects would still emerge and be defined by the learners.

Figure 2.2: Model for designing constructivist learning environments



Source: Jonassen, 1999.

The characteristics of ill-structured problems (Jonassen, 1999) are unstated goals. Constraints, multiple solution paths or no solutions, multiple criteria for evaluating solutions, uncertainty regarding the concepts, rules, and principles to use, or even no general rules and principles for predicting the outcome, are required to make and defend judgments. In a trans-concept study, Jonassen & Rohrer-Murphy (1999) applied the concepts and components of activity theory as a possible framework for designing computer based CLEs. Besides the existence of constructivist learning environment, there exists different salient features of constructivist learning approach.

Salient Features of Constructivist Learning Approach

Constructivist learning emphasizes active learning over direct instruction, integrated regulation, cognitive activity within complex authentic problems, and highly contextualized learning activities. According to Chien Sing (1999) constructivism has certain key features like active participation by learners, recognition of complexity, multiple perspectives, and real world contexts. It also holds particular stances on issues such as objectives, entry behaviors, assessment and errors. Rapid change, a feature of life, requires adaptability, flexibility, and problem solving skills since the latter part of the 21th century. To succeed in this context, learners should undertake self-initiated exploration of resources and active participation with learning content, activities, and environment. Instructors and teachers should not focus merely on transmission of information to passive learners, by deciding themselves what and how they should learn (Savery & Duffy, 1995). Instead, the emphasis should be on tasks, experiential activities, and alternative ways of stimulating cognitive growth and supporting learners by providing rich learning environments. In such learning environment, students can contextually interact, explore, and extract relevant information.

The constructivist school claims that the objectivist approach whether cognitively or behaviorally based on reducing complexity, may be misrepresenting the thinking and the mental processing. According to Savery & Duffy (1995), academic content has inherent complexity. It attempts to simplify learning for the sake of efficiency. Effectiveness may actually restrict mental processing, rather than engaging and enhancing it. Cognitive conflict is a stimulus for learning (Savery & Duffy, 1995). Chien Sing (1999) proposed that exposure to the real environment provides opportunities to address cognitive conflict or puzzlement. Learners reduce complexity themselves by interaction, inquiry, and exploration. Information generated are to be meaningfully processed, related to prior information, and applied to new situations beyond the immediate assignments or examinations. The accommodation of new knowledge within existing mental models is a step towards resolution of such conflict and confusion.

Teacher as a facilitator must present learners with various perspectives in an issue and use different approaches while presenting the same subject matter so as to make learners able to evaluate alternative understandings. Real world tasks are different from well structured single solution textbook problems. They do not have well defined pre-determined solutions such as those encountered in objectivist learning (Savery & Duffy, 1995). Interaction with the environment helps learners to identify in-congruencies between hypothetical scenarios of the world they study in and the real world.

In this connection Dodge (1996) emphasized that students should assume responsibility for their own learning and success. They should be encouraged towards self-regulation, planning and setting goals, assessing progress, determining their own strategies, and making adjustments in response to errors. He further added that tasks and activities should be engaging and relevant. Activities should have sufficient depth and complexity to stimulate the real world. The overall approach should motivate learners intrinsically, helping them to be absorbed and attentive to explore the resources.

Proponents advocate that knowledge construction occurs through social negotiation, rather than via inter-learner competition for recognition. The viability of individual understanding can be evaluated by social negotiation. Learners share and debate perceptions and interpretations in this regard (Savery & Duffy, 1995). Dodge (1996) considered collaboration with other learners to be preferable to individual learning. Learners within constructivist systems participate in negotiating their own learning goals, and thus different learners have different objectives. In contrast with the objectivist's bottom up specification of entry behaviors, constructivists have a top down, just-in-time approach that fills gaps in prior learning whenever needs arise. Responding to criticism of the lack of prescribed entry behaviors, Perkins (1991) acknowledged that mechanisms should be used to provide learners with adequate support in managing complexity.

In case of assessment to be valid, it should be embedded in the context of learning rather than based on testing in a de-contextualized academic setting. In constructivist learning, the focus of assessment is on what knowledge learners construct in real world contexts, based on authentic learning tasks (Jonassen, 1991). Learning and tasks may differ from one learner to another. In this connection, assessment must be in terms of authentic task performance (Cunningham, 1991). Dick (1991) concluded that assessment is the greatest challenge in constructivism, suggesting that constructivist assessment measures learning gain rather than investigating whether learners master specific skills. Due to the collaborative nature of constructivist learning, an issue arises when group work is assessed and individual efforts are difficult to determine. Assessment of individuals can only be done during actual task execution. It further increases the responsibilities on the part of educator. Constructivist assessment and evaluation of learning are complex and demanding processes. They entail multiple aspects and multiple evaluators. Constructivist epistemology explains that reality is individually and socially constructed on experience, and learning can be estimated only through observation and dialogue. If constructivism is a valid approach for the presentation of instruction and promotion of learning, it should also provide valid criteria for the evaluation of the learning. Jonassen (1994) proposed constructivist evaluation criteria including goals of learning and goals of evaluation, context of instruction and context of evaluation, and also evaluation beyond domain knowledge. This type of assessment as proposed by Jonassen should be integrated into instruction, so that both educators and learners are aware of the progress. Self monitoring also enhances learners' meta-cognitive awareness.

Brooks and Brooks (1993) in line with a constructivist classroom explained that the teacher as facilitator needs to formulate classroom lessons that are flexible enough to meet the needs and interests of a student. But the lessons are to be relevant to the required curriculum (Jonassen, et al, 1999). In the constructivist learning environment, the role of the teacher is to organize information around conceptual clusters of problems, pose questions and create situations in order to engage the students' interest (Hanley, 1994). Cain & Cain (1997), learning in such environment, emphasized that the teacher is not the deliverer of knowledge, but the facilitator and intelligent guide who engages student in learning. Students can only construct knowledge according to their developmental stage and their pre-existing knowledge base. Teachers should pose problems of emerging relevance and assess learner learning in the contexts of daily teaching, embedded directly into the current activities. A constructivist teacher acts as a mediator between learners' prior knowledge and their lived world's experience. Creating such learning environment helps the leaner to develop increasingly complex understandings and skills (Wilson, 1997). A constructivist teacher is also seen as a facilitator, who supports, guides, organizes and designs appropriate learning tools, and provides feedback to the learners (Wilson, 1995). Bertrand, (1995) contends that the teacher's role in a constructivist learning and teaching environment is to take into account their learners' learning processes and knowledge, and also to find out what learners know, as well as their spontaneous responses. It is evident that knowing and understanding where the leaner is in terms of learning are fundamental aspects of constructivist teaching.

Constructivists are in line that learning is personal discovery, based on the result of learners' intrinsic motivation. If the learner is the active agent, the implication for the teacher is to change from a disseminator of information to a facilitator. In this sense, the learner's individual development is at the centre of instruction, rather than a lesson plan (Gierbler, 2000). Fardouly (1998) stressed that considering the characteristics of a constructivist approach to teaching and learning, the learner decides what he or she needs to learn by setting personal learning goals and through their own activities and interaction with others construct meaningful knowledge for themselves. According to Wilson (1995), constructivist learning environments provide learners with opportunities to actively choose their own learning activities, control their own pace and direction, support one another with co-operation, use a variety of tools and information in their pursuit of learning goals (outcomes), and solve problems (problems-based learning).

The constructivist approach contributes to the validation of instruction that is less defined by pre-specific objectives and more open to the initiative of the teacher and learners. As a result, instruction depends more on context sensitive decisions and resources (Wilson, 1995). Fardouly (1998) suggested that a constructivist approach to teaching and learning is both an individual and a social process, and that learners construct meaningful knowledge for themselves as a result of their activities and interaction with other. Constructivism thus puts the learner in charge of his or her learning, and the teacher is viewed as a facilitator.

Views and Controversies about Constructivist Learning

Constructivism goes beyond cognitive learning models and overviews the reaction to constructivism from various theorists which are also referred to as the paradigm wars. Cognitive psychologists propose that the role of mental processes is to represent the real world, doing so by an appropriate sequence of mental activities. Even Piaget considered constructivist epistemological philosophies, and viewed mental constructions as representations of the real world. Contemporary cognitive theorists, however, questioned whether the mind should transfer knowledge from the external world into the human memory or they produce their own unique conceptions of events and objects based upon individual perceptions of reality (Jonassen, 1991). Constructivism assumes that learners construct the meaning of objects/events by interpreting perceptions in terms of their own experiences, interactions, beliefs, and biases. There is a strong link to collaborative learning. Constructivists refer to shared/negotiated meanings achieved by learners together with a teacher or other learners. Collaborative learning resembles with social constructivist strategy (Gruender, 1996).

In the late 1980s and early 1990s constructivism took the educational world by storm. Initial publications propounded the philosophy but offered little in terms of alternative models of instructional design. The omission of the old concept fueled the reactive criticism from proponents of the traditional models, and un-leased a vigorous debate. Constructivists faced the paradox – how could objective reality and externally correct meanings, prescribe systematic procedures for instruction? It would be much more appropriate to suggest guidelines and principles than to specify prescriptions and systematic procedures. However by the mid 1990s flexible but pragmatic constructivist models were in use. The guidelines for open learning environments and problem based learning were in harmony with true constructivism. Constructivism is more concerned with true learning than with instruction. A balanced view, presented by Dick (1991), pointed out that arrangement for constructivist learning opportunities is costly. They require technology to implement, and are difficult to evaluate. However, after twenty years, the two limitations are no longer valid that is the technologies of the internet and World Wide Web removed that difficulty. They are tailor-made for constructivist learning. He also raised the salient issue of the epistemology of constructivism- expressing doubt whether it is true instruction. Dick defined instruction as an educational intervention driven by specific outcomes. Objectives, materials, and procedures are targeted towards these goals and assessment is geared to determine whether the desired changes in behavior (i.e. learning) occur. Direct instruction is replaced with task to be accomplished or problems to be solved that have personal relevance for learners. Major changes have occurred in the realms of learning and instruction. Constructivism, as proposed by theorists a decade ago, shocked classical instructional designers. In the current learning centric culture, traditional instructors are out of line. It is not considered correct to speak of prescriptive instruction – the idea is to facilitate learning and in a democratic educational community by which the learner is considered as powerful as the facilitator (teacher). Constructivism is strictly non-prescriptive, a philosophy contrary to the norms of instructional theories and systemic procedures designed to deliver information and skills to the learners. Dick (1991) accepted constructivist proposals regarding learning contexts and multiple exposures to transfer from academia to the real world. Constructivists themselves, realize that constructivism, although learner centered, it may be intimidating and frustrating to learners due to its complexity, authentic tasks and the lack of specification of appropriate entry behaviors. Perkins (1999) proposed a way of handling cognitive complexity. In conventional instruction, learners are presented with, and test on simplified models in educational settings – an approach which Perkins called conflict to be buried. In constructivist learning in contrast, conflict is faced challenging learners by avoiding the inconsistencies of over-simplification. This tends to induce the cognitive conflict. A middle route could be conflict deferred, whereby learners are invited to learn a new way of thinking and talking about phenomena. The concept should be consolidated with simplified educational model and then the relationship should be explored. The constructivist approach has interlinks and controversies with different cross paradigms regarding views and controversies.

Cross-Paradigm and Constructivism

Certain characteristics and features transcend paradigms – they are aspects that must be considered in most kinds of instruction, regardless of the underlying philosophy. Such issues are collaborative work within a learning event, and the matter of creativity in instruction so as to motivate learners and meet affective needs. These are introduced in this section suggesting the practical ways of achieving them (Duffy, 1991).

Cooperative learning and collaborative learning have become standard practices in the 1990s. Collaborative learning can be implemented in various ways, but usually refers to groups of learners working jointly on a project with the intention of producing a joint product. This can be done either by face to face contact in classroom situations or in distance learning situations through computer mediated communication. Panitz (1996) explained the distinction between collaborative and co-operative learning. According to him, collaborative learning is a philosophy of learning more than just a classroom technique. It respects each group member's individual abilities and contributions. Authority and responsibility are shared within a team, and the underlying premise is consensus building. Collaborative learning ties into the social constructivist movement, and practitioners tend to apply this approach in the classroom, at meetings, in the community, and in their homes. The emphasis is on active participation/ interaction on the part of both learners and instructors. Co-operative learning is a set of processes whereby people work together to accomplish a specific goal or to develop a content specific product. It is more directive than a collaborative system and is usually controlled by an instructor/ teacher that is it is teacher-centric, whereas collaborative learning is learner centric. Collaborative learning empowers students in doing tasks that are frequently open-ended, whereas in co-operative learning, the instructor retains ownership of the task, which involves a closed problem with a correct answer or predictable solution (Panitz, 1996). In general, collaborative learning is broader than, and can be considered as a super class of co-operative learning. Co-operative learning is the better means to achieve mastery of foundational knowledge, but once students have reached/attained competency in a field, they are ready for collaborative work. Both learning are effective learner-to-learner educator paradigms, particularly in the context of interactive environments where students take more responsibility for their own learning with a sense of responsibility toward their peers (Panitz, 1996).

A learner centered paradigm views learners holistically considering both their cognitive and affective interpretations of learning situations. Learner-centeredness transcends theory and paradigm boundaries. In a learner centric situation, the role of an instructor or teacher ranges from directing and controlling instructions to facilitating and managing learning. Norman and Spohrer (1996) suggested that learner centered education can be best accomplished when problem based teaching approaches are used. This tends to match the problems associated to learning with the learners' interests and needs. Media and technologies also play a significant role in learner centricity. Norman and Spohrer (1996) advocated the power of computer based instruction and use of multi-media technology to engage learners with their rapid interactivity and powerful provision of information. Instructional methods selected are supplemented with the use of media to support human cognitive processes, to engage learners to optimize strengths, and to minimize weaknesses in teaching learning process. Dick (1991) pointed out that in true constructivism, designers offer learners' discretion to select the content they study, the resources they use as well as their approach to the topic. Reigeluth (1997) highlighted that customization is the most important key landmark that distinguishes instruction and learning in the information age from that of the industrial age. Interactive television is now in reality. All these paradigm shifts resulted from the information revolution and from its associated technologies. Education and training must keep pace with these changes and instructional theories should accommodate the concept of learning experiences geared to the requirements of individual learners.

Creativity in instruction is strongly related to the affective and motivational aspects of learning. In an instructional context, creativity is generally equated to engaging learners and is considered synonymous with instruction that motivate learners. In relation to an alternative approach to the epistemology of creativity, Rowland (1995) viewed that the term ‘creativity’ when applied to a design product, focuses on uniqueness by bringing beneficial change to a problematic situation. This study holds creativity as a motivating and engaging force. Designers express their idea via a medium (Kozma, 2000). A sound understanding of media and its relationship to design and learning can inspire creativity and enable powerful designs. A most important aspect of creativity is the use of instructional/ learning methods that engender creativity within learners themselves. Not only should learning and instructional materials be creative, but they should also foster individual and environmental creativity among their target learners. Creativity and the power of educational processes and products are directed to hold attention strongly to relate to arise motivation in the learner.

Extrinsic motivation is another aspect associated with reinforcement external to the work of learners for example: prizes for top achievers. Intrinsic motivation and de-motivation are related to internal states or effects like senses of anticipation, challenge, satisfaction, dissatisfaction, frustration, etc (Kozma, 2000). Motivational design (Keller, 1983) entails instructional strategies that motivate learners and do not frustrate them. In the current paradigm of life long learning, motivational characteristics in adult learning materials can contribute towards positive attitudes in those undergoing training and re-training. Norman and Spohrer (1996) asserted the motivational value of interactive multi-media technology. In a current trend towards problem based learning, a well-chosen theme can serve as primary motivator. The prime purpose of instruction is to promote learning. Creativity in instructional methods must remain supplementary to learning. Where materials and resources result in engagement and fun, these aspects must enhance the product without dominating its status. The challenge to instructional theorists, designers and educators in general is to synergistically integrate creative motivational and unconventional approaches to create instructional materials and events that effectively promote authentic learning. Ideally, instruction should be enjoyable, as well as effective and efficient (Keller, 1983).

Learning Focused Paradigm of Instructional Theory

Due to changed philosophies and dramatic advancement in information technology, major changes have occurred in the domains of instructional and learning theories. The change has been particularly in the associated disciplines of the design of instruction and the generation of learning environments. Reigeluth (1996) termed it as a new paradigm of instructional theory. He has proposed new paradigm of learning focused instructional theory that goes beyond the basic methods. For Reigeluth, such theories should provide guidelines for the design of learning environments that offer learners appropriate combinations of challenge and guidance, empowerment and support, as well as, self-direction and structure. Learning focused theory should address the issue of using and choosing between the wide varieties of current variable methods, such as project-based learning, problem-based learning, simulations, tutorials, and team-learning.

The user-designer concept of systems design theory refers to the approach where learners have decision-making roles regarding the instructional methods they use (Reigeluth, 1996). The instructional designer's role would move from extensive direct instructional decision making towards determining the mechanisms of decision making. This is in line with cognitive theory, which argues that learners' progress and attitudes are continuously tracked and monitored, so that decisions about appropriate instructional strategies are taken into account for individuals or teams, during instruction, rather than designing for an entire body of learners preceding instruction. In this connection, learners should be able to decide under varying degrees of guidance and instructor-modification both about what to learn (content) and how to learn (strategy). Vincini (2001) reflected on participatory design methods and their worth in achieving learner-centered design to add value to traditional instructional design. The separation of roles of instructional designers and teacher does not usually occur in formal education in Nepal. The separation of roles does, however, occur in vocational and other training situations.

Diversity of New Paradigm of Instructional Theory

Reigeluth (1999) has expressed the diversities of new paradigm of instructional theories and models. The diversity relates to varying values and to different kinds of learning promoted by the different contexts and situations. Traditionally, instructional design process models have relied heavily on research and empirical data about which methods work best, but the instructional process works best depending upon the qualitative values and associated criteria that are used to select the methods.

An analysis from the viewpoint of educational psychology provides enrichment and insight on the evolution of instructional and learning theories. It approaches cognition and learning from the latter perspective related to the traditional and emergent instructional theories. Greeno, Collins, & Resnick (1996) concluded that the current educational research is undergoing a major advancement that will deepen the theoretical understanding of the fundamental processes of cognition, learning, and teaching. It contributes to the practice of education. The fields involved in this cross-disciplinary paradigm are cognitive science, ecological psychology, ethnographic anthropology, and sociology.

Greeno, Collins & Resnick (1996) illustrated that under behaviorist/ empiricist view, knowing is based on an organized collection of connections among elementary mental or behavioral units. One way in which it is educationally implemented is via stimulus-response associations. Similarly, they defined learning as the process by which knowledge is increased or modified. Under this behaviorist/ empiricist view, means of effective learning are shaped according to the learners who become oriented to the general conditions. Under this condition, learning occurs, and desired responses are reinforced. The classical conditioning of this approach identifies required behaviors and responses. As a side effect, important unintended learning also occurs, so called incidental learning. Transfer of learning, i.e. applying knowledge in new situations, is a vital issue in educational psychology. Transfer under behaviorist/ empiricist view, is the strengthening and adjusting the associations between stimuli and responses. This can be done by personalizing instruction that is supplying feedback contingent on the individual learner's response, as is done by programmed instruction and computer based learning systems (Greeno, Collins & Resnick, 1996).

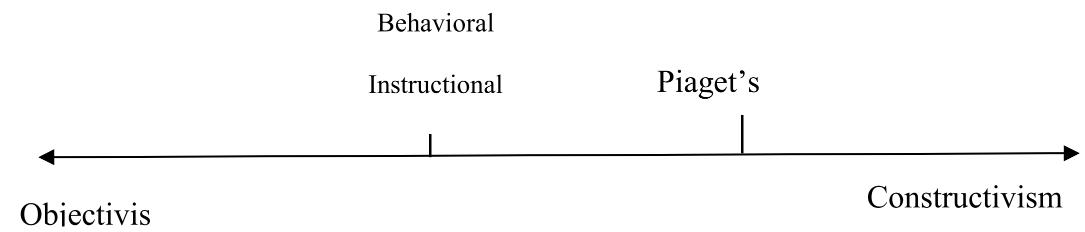
Cognitive/ Rationalist's views knowing as having structures of information and cognitive processes that recognize and construct patterns of symbols to understand concepts. Abilities like reasoning, problem solving, and analysis also occur in the same way (Greeno, Collins & Resnick, 1996). Learning is believed to occur via general schemata for understanding and reasoning according as in Piaget's (1988) theory of children's cognitive development. Furthermore, learning is viewed as conceptual understanding that transforms the learner's significant initial understanding, rather than simple acquisition of knowledge on a blank slate. Learning is considered to occur via intellectual activity, and understanding is gained by an active process of construction rather than by passive assimilation of information or rote memorization. This cognitive/ rationalist view incorporates a constructivist program with studies of cognitive development in specific subject matter domains. When learning is viewed as the acquisition of knowledge and the understanding of information, concepts, principles, and strategies, then motivation and engagement are viewed as intrinsic interest in a domain of cognitive activity. Cognitive researchers guard against rewarding learners extrinsically. Malone's framework (1981) for intrinsic motivation proposed challenge, fantasy, and curiosity to make learning environments more engaging.

In pragmatist/ socio-historic view, Greeno, Collins & Resnick (1996) addressed the way that knowing is distributed in the world among individuals (with relation to the tools and resources they use) and communities (with regard to their practices and co-operative activities). Knowing can be implemented by participation in the practices of communities. Communities are groups of individuals, and the abilities of groups are considered to be knowing i.e. collective knowing as well as individual knowing are both considered. This kind of knowing within the context of social practice has traditionally been studied more by anthropologists and sociologists. The relevance to current teaching is the importance of learners being able to participate in social practices, both in and out of formal educational settings (Reigeluth, 1999). When knowing is viewed as the practices of communities and the abilities of individuals to participate in those practices, then learning is the interactive strengthening of those social practices. Such learning includes forms of initiation in which beginners are originally peripheral to the community activities for observing and practicing. In the view of learning as participating in a community practice, transfer is a problem. Many of these resources and supports do not carry over to different communities or situations. The view of learning focuses on engagement that maintains interpersonal relations within the community or a satisfying interaction with an environment. An example of powerful social learning is young children's learning to speak their home language by communicating with the family.

Constructivism and authentic contextualized environments are bringing major changes to traditional classroom instructions. In certain level, they are perceived as a threat. The paradigm war (Willis, 1998) is a major topic in social science and education. It remains to be seen whether the alternative philosophies will transform the discipline of instructional design, both in the way it is taught and the way it is practiced. Certain designers differ with the Dick and Carey model on a philosophical level, perceiving it as obsolete, positivist, and objective thinking. They argued that there should be a paradigm shift towards constructivist frameworks. Chien Sing (1999) suggested that change should be perceived as a catalyst that can contribute to dynamic and authentic learning environments.

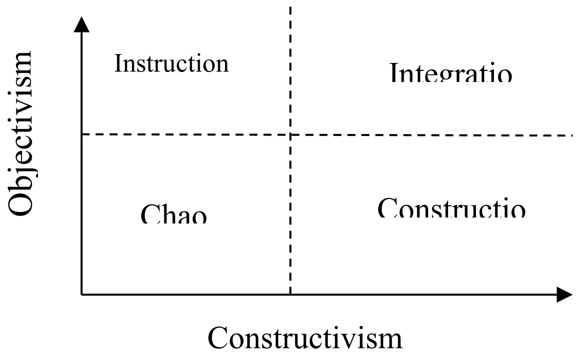
Jonassen (1991) acknowledged that situations exist where objectivism and constructivism are compatible in which complementary design tools offer different perspectives on the learning process. Braden (1998), a proponent scholar of the systematic development of instruction, claimed that there are always domains where systematic instructional design and structured instruction are the most appropriate methods. Similarly, Willis (1998) pointed out that constructivist learning covers a broad scope within which there remains a place for direct instruction and for the learning of basic information. Students do not have to discover everything for themselves. Sometimes direct instruction is appropriate, and sometimes less structured learning environments, using rich resources for undirected learning experiences may be relevant. Constructivists are concerned about boring, out of context instruction, as well as the type of instruction that produces inert knowledge, which is hard to apply or transfer. The objectivism (externally mediated reality) and constructivism (internally mediated reality) tend to take the extreme positions. Figure 2.3 depicts Jonassen's portrayal of continuum between extreme objectivist and constructivist poles.

Figure 2.3: The Objectivist- Constructivist Continuum



An alternative approach (Cronje, 2000) is to place objectivism and constructivism on independent axes at right angles (90^0) on the Cartesian plane, instead of placing them at extremes (180^0) on the same axis. The significance of this model is a proposed integration of the two traditionally conflicting views to present them as complementary approaches. Cronje analyzed various learning programs and developed a pragmatic incorporation of both objectivist and constructivist elements in their learning events. This model forms an appropriate representation of the findings. When objectivism and constructivism are juxtaposed on axes, as illustrated in figure 2.4, the four quadrants result. It shows the degree of objectivist and/ or constructivist learning for a particular content domain. Each of the four: instruction, integration, construction, and chaos, has its own valid place in the field of teaching and learning.

Figure 2.4: The Objectivist- Constructivist Plane



Source: Jonssen, 1999

The chaos quadrant, low degree on both objectivism and constructivism represents incidental learning. Instruction is high on objectivism and low on constructivism, and is the domain of programmed learning, tutorials, lectures and drill-and-practice. The construction quadrant corresponds closely to the conventional views of constructivism, constructionism, and cognitivism. When objectivism/ instruction and constructivism/ construction are combined, the fourth quadrant of integration arises. This is the domain that typically emerges when an instructional designer conducts goal analysis to determine required learning outcomes, and then applies objectivist/ instructionist and constructivist/ cognitivist learning approaches to achieve the desired outcomes (Cronje, 2000).

Constructivist Learning Design in Practice

Conventional instruction, from pre-school to adult education, is traditionally based on a system where topics are subdivided and taught according to prescribed procedures. An evolution, almost a revolution, within this system is currently energized that has dramatic influence upon all aspects of teaching and learning. There is emphasis on the context within which learning occurs, addressing both the presentation of content and the approaches to be used by individual learners. They encounter and construct knowledge and acquire skills. There is a clear shift from a fixed autocratic approach to flexible and learner-centered approach within a context of guidance and support. There is also awareness of the utility of technology, yet avoiding control by technology (Reigeluth, 1999). The new learning theories and models conceive that the most effective learning occurs in authentic contexts, promoting the utility of open ended and problem based learning within interdisciplinary learning environments. Furthermore, instructional and learning theories are being broadened to encompass the affective domain. Meanwhile learner-achievement and leaner –attitude is receiving increasing attention. Context should incorporate more than just the authenticity of learning situations. It should also take recognition of learners' values and where appropriate, aim to guide values and norms. It appeared that the underlying philosophy of instruction has connection with learning event. However, the major thrust of instruction and impacts were given upon the strategies used and features implemented as (Willis, 1998) stated:

> We do not have one large bowl of instructional strategies from which to make our selections each time we design instructional materials. We have many bowls, and they contain families of instructional strategies that are based on different theories of learning and instruction. There is a behavioral family of instructional strategies, a cognitive science family, and at least two constructivist families. The selection of an instructional strategy should be made from within a theoretical framework that guides decision making (pp146).

This does not mean as Willis pointed out and as Hannafin et al (1997) proposed that all the strategies selected originate from the same theoretical base. They are to be chosen within a theoretical context. In determining the strategies, features and characteristics of instructional materials and learning events, the instructional designer is expected to consider the type and purpose of learning. The prime issues, therefore, are the nature of the learning event itself and an appropriate theoretical foundation to guide process of those learning events. In 1900, Dewey (cited in Reigeluth, 1997) called for a linking science between learning theory and educational practice. Methods of applying learning and instructional theories were incorporated into the discipline of instructional design (ID), which relates to structured processes for the generation of instructional products and strategies. Not only there is a close relationship between contemporary theories of instruction and learning but also there is a strong relationship between the theoretical paradigms and the technologies used to implement them. The constructivist view summons instructional designers to make a radical shift in their thinking and to develop rich learning environments that help to translate the philosophy of constructivism into actual practice (Tam, 2000). The designer's task is to provide the learners with control (or empowerment). The learners then examine the materials and draw their own conclusions. The key is to provide a wealth of materials and techniques for examining them in different sequences and under a high degree of learner control. Lebow (1993) proposed five principles toward a new mindset of constructivist values that might influence instructional design as:

a. Principle 1: Maintaining a buffer between the learner and potentially damaging effects of instructional practices,
b. Principle 2: Providing a context for learning that supports both autonomy and relatedness,
c. Principle 3: Embedding the reasons for learning into the learning activity itself,

d. Principle 4: Supporting self-regulated learning by promoting skills and attitudes that enable the learner to assume increasing responsibility for the developmental restructuring process, and

e. Principle 5: Strengthening the learner tendency to engage in intentional learning process, especially by encouraging the strategic exploration of errors (pp54).

These principles support many of the views of constructivism in which objects and events have no absolute meaning, rather, the individual interprets each and constructs meaning based on individual experience and evolved belief. The constructivist design principles, implemented within the framework of the values and procedure outlined in the above instructional design model, can lead to a variety of learning environments, such as cognition in real-world context, cognitive flexible learning or collaborative learning. Thus the instruction should be delivered in the relevant contexts (Willis, 1995). Hannafin, Land and Oliver (1997) pointed out that the design task is one that provides a rich context within which meaning can be negotiated and ways of understanding can evolve. Tam (2000) argued that constructivist designers need to develop procedures for situations in which the instructional context plays a dominant part, and the instructional goals evolve along with the learning progress. According to Duffy and Jonassen (1991), the roles of the instructional designer becomes the provision of context, and assist the individual in making sense of the environment as it is encountered. Many researchers proposed that instructional design can become an essential part of the learning environment, in view of constructivist learning theory. Riel (1994) stated that instructional design can be a catalyst for change in classroom processes. This is because it provides a distinct departure, a change in context that suggests alternative ways of operating. It can drive a shift from a traditional instructional approach towards a more diverse set of learning activities that include knowledge building situations for learners. In this context, Tam (1994) asserted that constructivist designers tend to avoid the breaking down of context into component parts as traditional instructional designers do, but they are in favor of environments in which knowledge, skills and complexity exist naturally. Constructivism has presented the challenge of re-conceptualizing learning as a constructive process in which information is turned into knowledge by means of interpretation, by actively relating it to existing bodies of knowledge, by the generative creation of representations, and by processes of purposeful elaboration (Resnick, 1996). Salomon (1991) maintained that constructivism and instructional design together have remade substantially the conception of the challenges of learning, and brought about new learning possibilities for almost all teaching and learning situations. It is evident that a mutual relationship exists between the constructivist perspective on learning and the interactive technology supported environment. This relationship promotes an increased level of motivation, knowledge construction and the development of social and communication skills among learners (Scheepers, 2000).

Traditional learning design holds an objectivist world view, based on the premise that the purpose of instruction is to transfer objective information and impart knowledge. Epistemologically this entails the direct transfer of a particular reality, without interpreting or reconstructing it. On the other hand, constructivism claims that learners can only interpret information in the context of their own experience, and that learning is individualistic. From the words of Jonassen (1991):

> Constructivism is not the panacea for all of the instructional problems in education and training, no more than other theories and technologies

> are. Yet all are designed to make learning a more realistic and meaningful process (pp 201).

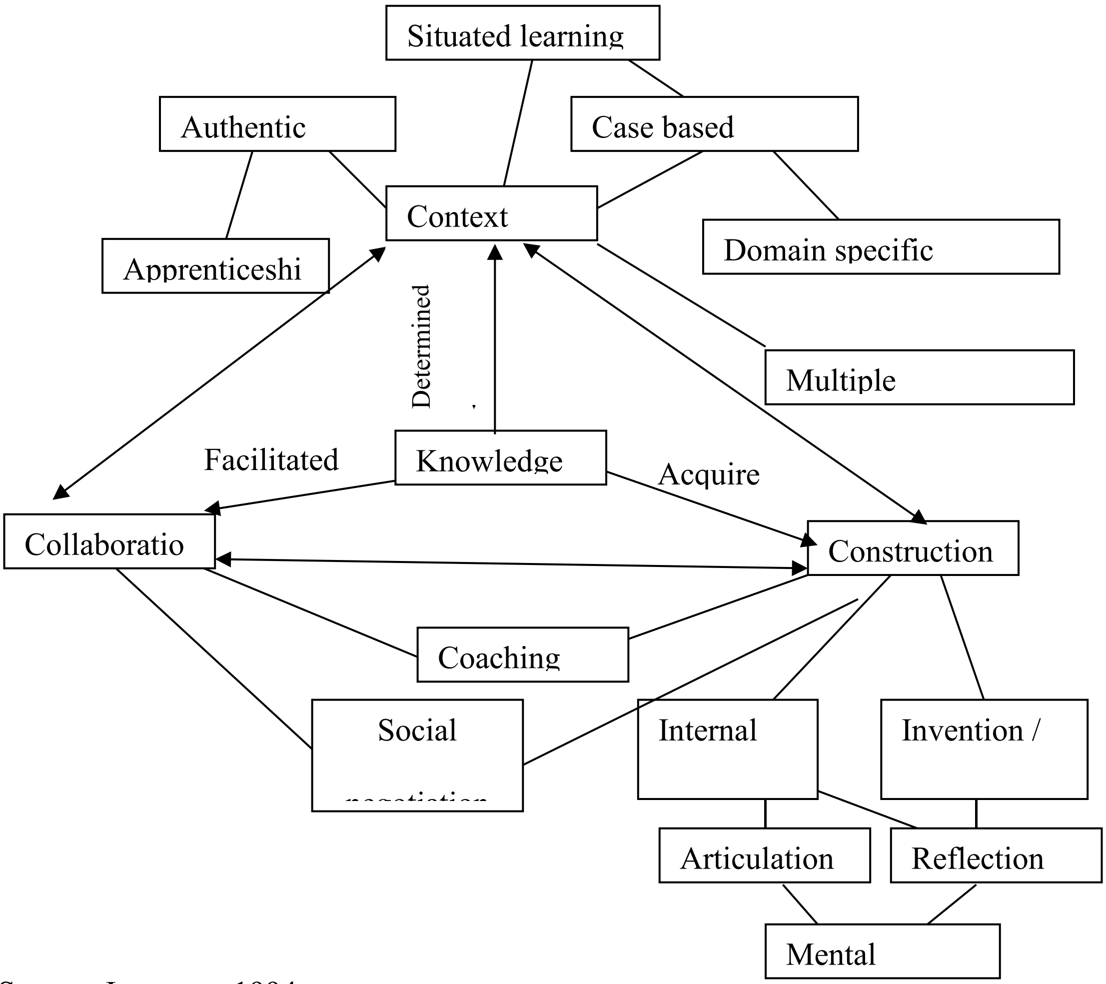
The implication of constructivism for learning design is that learners should be enabled to construct their own relevant and conceptually functional representations of the external world. The two approaches involve different roles for instructional designers, since constructivist learning occurs less according to a predetermined sequence of instructional events and more within supportive learning environments where tools and techniques must be provided. Winn (1992) highlighted three differences between the basic assumptions of traditional learning design and those of constructivism.

Once instruction is designed, it must be delivered. ID is so closely associated with educational technology to teach content. Constructivists use it to promote learning. Full technologies are systems that contain information to be transferred to the student (e.g. Computer Assisted Instruction - CAI and Computer Assisted Learning - CAL), while empty technologies are shells or tools that allow students to explore and construct (Winn, 1992). As there is little emphasis on instruction and performance, and delivery systems do not deliver content, what remains for the constructivist designer to design? First, they have to continue designing instruction in basic knowledge in well – structured domains. Second, strategies must be designed to support learners as they construct meaning. By shifting instructional decisions to the time of delivery, the design of instruction is re-integrated with its implementation. The constructivist debated initially to promote principles of constructivist learning, but fell short in proposing practical approaches. By the mid 1990s, however, constructivism was impacting on educational practice with the emergence of constructivist design (C-ID) models. Their arrival generated considerable discussion within the instructional designers.

As constructivism progressed from a philosophy to an instructional approach, general principles for constructivist instructional design, and its attributes, were suggested. Examples are Lebow's (1993) constructivist values, Jonassen and Duffy's heuristics for designing general constructivist environments (Duffy & Jonassen, 1991), Kozma (2000) proposed cultural changes to educational technology research and development, and Willi's (2000) design principles. This present study has attempted to trace the concretization of constructivism within general principles of constructivist instruction and instructional design.

Constructivism has major implications for instructional design, in particular, in the generation of learning and instructional environments. Explicit constructivist design models are complex. What works in one domain is unlikely to transfer to another content domain. In the early 1990s certain common characteristics were identified for constructivist instruction (Cunningham, 1991). This suggested significant changes to the key features of traditional ID models, including objectives, task analysis, strategies, evaluation and roles. Lebow (1993) investigated the implications of constructivist philosophy for instructional design. By the mid 1990s, constructivist learning was maturing with the clear emergence of concepts such as learning environments and contextualized learning. Jonassen (1994) tentatively identified a web of constructs common to most constructivist projects. The elements identified are process oriented rather than product oriented, and is based on the three attributes namely construction, context, and collaboration. The web of constructs and its interrelationships has been shown in figure 2.5.

Figure 2.5: Jonassen's Web of Constructivism



Source: Jonassen, 1994

As constructivist concepts like learning environments and learning via authentic tasks became established, attention was focused on the role of the learner in this new-style instruction. Constructivism can be implemented to varying extents (Perkins, 1991). There is BIG constructivism, proposed by Bruner (1973, cited in Perkins, 1991) as an acronym for Beyond the Information Given. Such an approach exposes learners to certain concepts, and then engages them in activities which challenge them to move beyond the initial information. It guides to generalize and refine their understanding. By contrast, a WIG approach, Without the Information Given holds back on direct instruction. Learners can be presented with phenomena and anomalies, and encouraged to explain and model them. Scaffolding is provided but not direct information. WIG is a way of implementing discovery learning and the construction of ideas, but Perkins (1991) viewed that it would be inefficient and ineffective in case of sole method of learning.

In the 1990s, interest grew in creating learning systems that differ from traditional direct instruction rather than promoting mastery of specific concepts (Hannafin, 1996). Open ended learning environments (OELEs) introduced interactive learning activities within a technological environment. Like CLEs, they emphasize contextual learning and represent a shift from designer managed learning to student-centric learning. OELEs are not restricted to a single paradigm, but there is a strong relationship with emerging psychological theories like constructivism and situated cognition. There are fundamental shifts in conceptualizations of the learner, knowledge, and the structure of the environment (Hannafin, 1996). Characteristics of OELEs are flexibly defined and they cover a broad spectrum (Hannafin et al, 1994). Their scope varies from micro-worlds, where relatively narrow but well-defined concepts are represented, to macro-level contexts where large sets of knowledge and skills are integrated.

Problem based learning (PBL) as the problem driven approach is another learner centric approach highly effective in motivating learners. As they take ownership of a project/ problem, they gain advantages over and above conceptual understanding and the generation of a solution or a product. Learners more easily retain learning acquired by their own efforts and acquire new skills, such as decision making, self-confidence, negotiation, accessing resources, and technical expertise – that stand them in good condition throughout the life. However, Problem based learning neither lends itself to teaching basic knowledge, nor to acquisition of sub-skills. Land and Greene (2000) emphasized the need for learners to become sophisticated consumers of information knowing how to locate resources, extract and organize relevant information, and synthesize items from various sources into a cohesive whole. Project based learning environment entails learner-directed investigation as they develop solutions to open ended situations. The projects are real world cases, inviting genuine research on the part of learners, thus contributing towards the construction of meaningful solutions. In project based, problem based or case based learning approaches, the educators chose problems that cover the necessary aspects of content and skills. Based on the constructivist practices, different learning design models have been proposed in line with the knowledge construction.

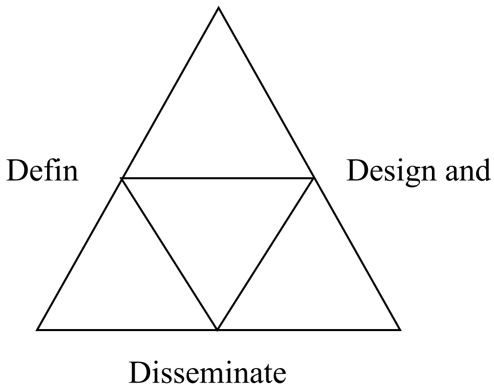
Constructivist Learning Design Models

Literature reveals that there are different learning design models and that they are like myths and metaphors for helping to make sense of our world (Ryder, 2002). This author argued further that whether a model is derived from whim or from serious research, it offers its user a means of comprehending incomprehensible problem. Instructional design gives structure and meaning to a problem, enabling the designer to negotiate his or her task with conscious understanding. For models, it helps one to visualize the problem, and to break down into discrete, manageable units (Ryder, 2002). Taxonomy of instructional design models can help clarify the underlying assumptions of each, and assist in identifying the conditions under which each might be most appropriately applied (Eric, 1997). The taxonomy has three categories that indicate whether the model is best applied for developing: individual classroom instruction, products for implementation by users, and a large and complex instructional system directed at an organization's problems or goals (Eric, 1997). In the context of this research study, the focus falls within the scope of designing and developing individual classroom instruction. Models for instructional design provide procedural frameworks for the systematic production of instruction. The models incorporate fundamental elements of the learning design process, including analysis of the intended audience and determination of goals and objectives, and may be used in different contexts. Depending on the situation, one model can be used for an entire course of instruction, or elements from multiple models can be combined (Braxton, Bronico & Looms, 1995).

Educational literature of the early 1990s abounded with articles pointing out shortfalls in the objectivist models of traditional instructional design, while expounding the benefits of constructivism and proposing that instruction should be practiced from this perspective. However, there was lack of pragmatic constructivist models that could be adopted by the learning design community to implement the alternative paradigm. Although various authors published general principles, constructivist theories view knowledge and meaning contextualized by emphasizing interpretation, multiple perspectives, and social construction of meaning. These values result in a paradox and are reluctant to propose their own model as the ultimate model of constructivist instructional design (Willis, 2000). This section sets several frameworks to trace the emergence of constructivist norms. As constructivist instructional design matured, the term C-LD models came into being. Can there be an ultimate constructivist learning design (C-LD) model? Or would it be a contradiction in terms to suggest an ideal constructivist approach to design? By its very nature, constructivism rejects any single objective reality, thus exclude a single classic C-LD model.

Willis (1995) who made well-formed suggestions in the recursive reflective design and development (R^2D^2) model, is a pioneer of constructivist learning design (C-LD). This is a constructivist-interpretivist approach to LD. It is based on constructivist learning theories, and also it is interpretivist with respect to its situation within scientific philosophies. R^2D^2 is non linear and is based on three components and two perspectives (Willis, 1995). The three components: define, design-and-develop, and disseminate, agree on three focal areas as shown in figure 2.6. Design and develop are the sources of two D's in R^2D^2. The components are addressed from the perspectives of two R's, namely recursion and reflection, which relate to the ways in which the instruction is developed. The figure indicates that there is no obvious beginning or end points.

Figure 2.6: The R^2D^2 Instructional Design Model

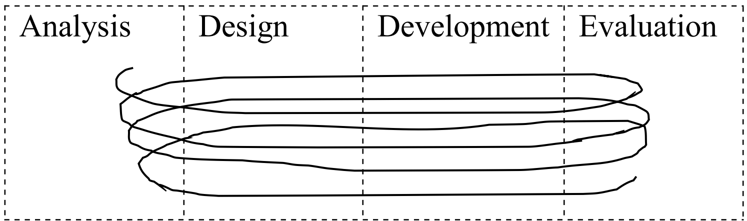


Source: Willis, 1995.

The three components of R^2D^2 mainly deal with definition focus, design and development focus, and dissemination focus areas. The revised model of R^2D^2 (Willis and Wright, 2000) is based on Willis' (2000) guidelines for constructivist learning design. R^2D^2 has been used to develop a wide range of educational materials from videos to electronic books and web sites. The description of the first version used certain standard LD terminology with different meanings. This led to confusion and thus the revised version more appropriately used terms from constructivist and related theories, and expanded the original model.

In the process of designing materials for constructivist learning, Cennamo, Abell and Chung (1996) proposed a general approach (the layers of negotiation model) for the design of products consistent with constructivist ideas. The model assumed that designing materials for constructivist learning environments implies revision of both the processes and the products of instructional design. Within this perspective, it is inappropriate to set learning objectives. The authors aimed to design materials guided by their assumptions about teaching and learning, reflected over the design process and compared the procedures with those prescribed by traditional models. The creators of this model did not follow a traditional model of instructional design, yet their model is indeed systematic. In the Cennamo, Abell, and Chung (1996) model, design of the materials evolves in a spiral, layered fashion, as shown in figure 2.7, proceeding cyclically with ongoing analysis, design, development, and evaluation, reaching deeper levels whenever additional data becomes available or relevant.

Figure 2.7: 'The Layers of Negotiation' Constructivist Design Model



Source: Cennamo, Abell & Chung, 1996

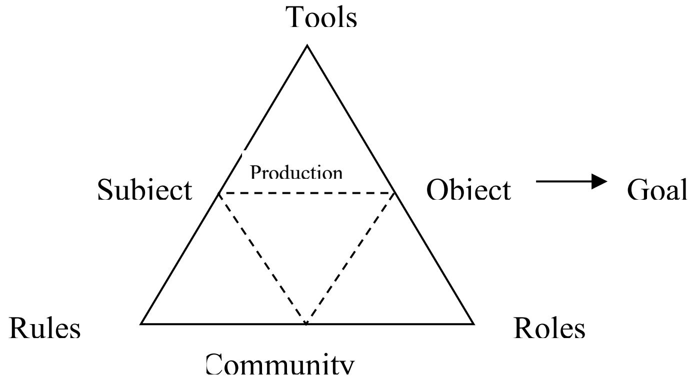
The layers of negotiation process differ considerably from traditional LD models. It incorporates process based versus procedure based design, question-driven approach rather than task driven, and spiral cycles instead of discrete stages.

Grounded design (Hannafin et al, 1997) is on the other hand applied to determine what characterizes a grounded constructivist learning environment. For constructivists, objects and events have no absolute meaning. Individual meaning is constructed and assigned according to personal experience and interpretation.

Constructivism downplays subdivision into component parts, favoring environments that incorporate knowledge, skill, complexity and contexts within which learners can negotiate meaning. Learning systems are founded on psychological, pedagogical, technological, cultural, and pragmatic considerations (Hannafin et al, 1997). For a learning system to be effectively based on a grounded design, these five foundations must be aligned so as to maximize coincidence and shared functions.

Activity theory (Jonassen & Rohrer – Murphy, 1999), which originated from the classical German philosophy of Kant and Hegel, is a framework for studying various forms of human practice as developmental processes, interlinking individual and social levels. It can be applied as a framework to model a constructivist learning environment. It postulates that learning and activity are interrelated. Conscious learning emerges from activity, rather than preceding it. The implication for designing instruction is that the context of learning and performance is vital. Activity cannot be understood outside its context. Relevant aspects are: the kind of activity, who performs it, what results from it, its rules and norms, and the wider community within which it occurs. The components of an activity are modeled on a triangle, as illustrated in figure 2.8. The three prime components are the subject, the object of the activity and the community in which they occur. The subject is the individual/s engaged in the activity, and the object is that which results or is sought, i.e. the motivating intention of the activity. In instructional design for example, the object may be a curriculum design.

Figure 2.8: Activity System

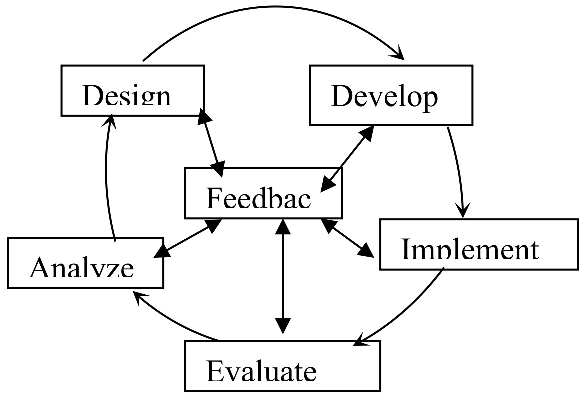


Source: Jonassen & Rohrer-Murphy, 1999.

The supporting components, the structural pivots on the apexes of the triangle, are the tools, the rules, and the roles used in the transformation process. For an effective activity, they must be specific to the nature and culture of the activity. Thus, tools alter the activity and are, in turn, altered by the activity as they adapt to its specifics (Jonassen & Rohrer-Murphy, 1999). The other facets of triangle are the rules of the activity and the way in which the division of labor is negotiated within the community. Since activities are contextually bound, an activity system can be described only in the context of the community in which it operates. The community negotiates the rules and roles which define the division of labor, such as the allocation of tasks. The overall activity consists of a goal-directed hierarchy, in which the major activity transforms into chains of conscious actions, which in turn collapse into more automatic operations. They become more familiar and are internalized. Certain assumptions underline activity systems and activity theory. These are minds in context, consciousness as the unifying factor, internationality, object-orientedness, tool mediation and collaboration. Jonassen & Rohrer-Murphy (1999) asserted that an activity system can be applied as a framework to model a constructivist learning environment (CLE). The environment should be ill-structured and complex, but relevant and meaningful to learners.

Among all, the ADDIE Model is the widely adapted model of learning design. ADDIE is an acronym that describes the five stages of the design process, namely: Analysis, Design, Development, Implementation and Evaluation (Andris, 2001). Figure 2.9 represents the ADDIE model of instructional design (Piskurich et al, 2000). Although the process of the model is mainly linear, it provides a systematic step-by-step approach in designing effective and objective instruction.

Figure 2.9: Basic ADDIE Instructional Systems Design model



Adapted from Piskurich, et al, 2000

While the process is a linear one, it is also spiral in nature: the evaluation step is not an end, but is the entry into a new level of analysis. According to Clark (2000), the analysis phase associated with the ADDIE model is typically called front-end analysis It occurs at the beginning of the learning design effort. It includes a needs assessment and a performance analysis to identify causes of and potential solutions to the problems. In conclusion, there seems necessity of selecting a best model for designing instruction.

Choosing a Learning Design Model

Different instructional methods or interventions, or combinations of several of these, may suit different instructional goals to be attained by different types of learners. One method may serve different purposes for different learners and there is a greater possibility of reaching a particular goal by employing different methods. Although there is no established one-to-one relationship between types of learner and methods, variety of methods may be supportive for different types of learners, (Elen & Clarebout, 2001).

Having described and discussed these various instructional design models, it is apparent that the "ADDIE" model might be considered as a generic model of learning design. It incorporates all the basic components of most of the models, and it is often the starting point from which new models are conceptualized (Seels & Glasgow, 1998). In the context of this research study, the ADDIE model of instructional design was used as a guide for the design and use of the technology-based interactive learning resources for the secondary school level science students. The discussion now moves on to overview the various authors' opinions: whether or not the approaches of the various paradigms to learning design should be integrated?

Some researchers advocate no fusion, suggesting that design can be effective only if it is closely coupled to a pure underlying theory. Bednar et al (1992), acknowledged that the field of instructional systems technology prides itself on diversism. A broad range of research on human learning is applied, and principles and techniques from various theoretical perspectives are placed within a practitioner's framework to achieve a particular learning goal or performance objective. Bednar et al, however, challenged this practice, arguing that abstracting concepts and strategies from their original theoretical framework strips their meaning by removing them from their underlying epistemological context. Practical methods of instruction cannot be separated from a theoretical framework as stated by Bednar et al (1992):

> Instructional design and development must be based upon some theory of learning and/or cognition. Effective design is possible only if the

> developer has developed reflexive awareness of the theoretical basis underlying the design (pp106).

In the context of the objectivism-constructivism controversy, Jonassen (1991) queried specifically whether traditional instructional systems design and constructivism can be compatible, due to their fundamentally different approaches to learning theory. Similarly, Willis (1995) doubted that the broad differences between educational technologists on different sides can be bridged. In response to this, Dick (1995) claimed that constructivism has impacted positively on systematic LD procedures without undoing their intrinsic flavor. In this connection, other researchers proposed accommodating alternative sets of values. Reigeluth and Squire (1998) argued from a pragmatic perspective that elements of objectivism, cognitivism, and consructivism can and should be combined in instructional models. The best designers select, apply, adapt, and extend attributes and components of various models and strategies to optimize instructional methods for the particular learning domain. It is not obligatory to accept one specific view point. Learning design should draw on various psychological theories and, in conjunction with various learning theories, collectively determining appropriate directions. Dick (1991) and Winn (1992) referred to the need of both: formal instruction based on traditional ISD paradigms, and situated learning within constructivist frameworks. Grounded design (Hannafin et al 1997) acknowledged the variety of sound validated theories and correspondingly accepted a variety of instructional and learning practices, provided that they are rooted in some established theoretical framework. This approach may be more realistic than a search for one true theory (Wilson, 1999).

A further noteworthy viewpoint is that direct instruction and constructivism are not always mutually exclusive. Learners can construct meaning from well designed direct instruction (Mayer, 1998). Reigeluth suggested that a descriptive scientist, such as a learning theorist, adopts a single theory and works with it but a prescriptive researcher, such as an instructional theorist, is pragmatic and open in addressing practical problems. Eclecticism and multiple perspectives are strengths for practitioners and even for theorists (Reigeluth, 1997). In deciding which theory to use, practitioners should consider factors such as kind of learning, the kind of learners, and constraints within the learning situation (Reigeluth & Squire, 1998).

Constructivist Epistemology of Learning Design

Learning design processes should be adapted or transformed so as to remain relevant on the cutting edge. Traditional ISD models are suitable for many forms of basic, direct instruction and practice, but do not lend themselves to the creation of constructivist learning materials. The passive learning of content is replaced by problem solving and learner initiative. Constructivism, as a broad theoretical framework, does not naturally give rise to systematic design models, it does not always require formal, and tangible learning materials. It yields learning philosophies as a foundation for LD and associated principles/ guidelines, although there are situations where C-LD processes exist for the development of constructivist resources (e.g. the R^2D^2 model, layers of negotiation models, and grounded design). LD should be situation specific and embedded in context (Hwang, 1996) and thus requires a continuous process of re-invention so as to meet changing requirements. Direct instruction is likely to play a less major role in the 21st century than it has in the 20th century. Therefore, a serious need exists to have sound philosophies and procedures for the development of resources and tools for the alternatives: problem-based learning and learner-centered environments like CLEs and OELEs. The researcher intended to answer the questions: Can varying theories be integrated in the design of learning and instruction? Can they even co-exist? The study promoted compatibility, complementarity, and a position of considered compromise on cognitive grounding:

1. direct instruction of basic knowledge can be enhanced by selected views of constructivism,
2. balanced constructivism holds challenging promise and is strongly related to learner-centricity, and
3. designers should integrate aspects of the available theories and strategies, so as to synergistically optimize on compatible and complementary stances.

In applying theory to practice, different theoretical perspectives are appropriate for supporting different kinds of learning. Within a major learning experience, there are different forms of knowledge and skills to be acquired. The processes are supported by different frameworks and practices. Each theoretical perspective and its associated implementations offer practices and tools that facilitate different kinds of learning among different kinds of learners, and at varying stages and in different parts of instruction.

In conclusion, society in the early 21st century is characterized by social consciousness. The implication for education is that instruction and learning should not be addressed merely in a pragmatic manner but rooted in a value system. Educational practice has traditionally been founded on underlying values and philosophies. The difference now is that values are made explicit and used by practitioners as the basis for decision-making. Education, training and instruction are changing due to various factors. Technological advances open up new possibilities, and a democratic user-centric culture promotes the acquisition of life-skills along with content learning. So far the science education is concerned, there has been little research regarding the direct effects of constructivist epistemology on learning science in classrooms. However, a substantial amount of recent research has been reported regarding the effects of constructivist based teaching strategies in this regard.

Constructivist Epistemology of Science Education

According to Keys (2000), several studies describe a potential research agenda for the teaching and learning of science as inquiry. He advocates that research has been focused on drawing the theoretical frameworks of cognitive and socio-cultural constructivism, cultural models of meaning, the dialogic function of language, and transformational models of teacher education. According to Mestre (1991), there are two main instructional practices found in today's education. One is the long prevalent practice, which results from the so-called transmission model of instruction (Mestre, 1991). In this model, students are introduced to content through lectures, presentations, and readings and they are expected to absorb the transmitted knowledge in ready-to-use form. Although it is not a model of learning, the transmission model makes a pivotal assumption about learning, namely that the message the student receives is the message the teacher intended. Within this model, students' difficulties in grasping a concept are interpreted as indicators. The presentation was not clear or forceful enough to be understood, or the student was just not able or prepared. Tishman (1993) maintained that many users of the transmission model believe that if they make the presentation coherent or persistent, for example by transmitting at a slower speed or in louder voice, then students will eventually understand. Teachers are inclined to believe that by speaking in shorter words and sentences, they can teach the big ideas in relativity to students. Perry (1968) argued that teachers should consider students' intellectual development not at a level where they can understand the abstract concepts. Child psychologist Jean Piaget described a mechanism by which the mind processes information. Piaget argued that a person understands whatever information fits into one's established view of the world. Piaget asserted that when information does not fit, one must re-examine or re-adjust his/ her thinking to accommodate the new information (Piaget, 1970). According to Piaget (1970), teachers need to be conscious of their students' cognitive development and strategically plan or develop curriculum that enhances logical growth.

The transmission model is often used largely by default rather than choice, because it is the instructional method by which students are usually taught. It may be the only instructional method some teachers know how to use. Not only does it lack theoretical justification, but also there is evidence that it is not the most efficient or effective model of instruction. Unlike the transmission model, the second major instructional practice, which has emerged over the last decade, begins with what is commonly termed the constructivist model of learning, constructivist epistemology, or simply constructivism (Mestre, 1991). This model contends that learners actively construct knowledge. The construction of knowledge is a lifelong process and at any time, the body of knowledge of individuals constructed makes sense and helps them interpret or predict events in their experiential worlds.

This view of learning contrasts with the view tacitly assumed in the transmission model. Constructivism contends that students are not sponges ready to absorb and use transmitted knowledge. The knowledge already written on their mental slates affects how they interpret new observations and how they accommodate newly constructed knowledge. During the course of instruction, if teachers are not cognizant of students' prior knowledge, the message offered by the teacher will not likely be the message constructed by the student (Mestre, 1991). At the elementary level, the debate has included a discussion of the benefits of activity based science instruction built on constructivist concepts. This is opposed by the benefits of more direct instructional methods based on textbooks. Research on activity based science programs, primarily from the 1980s, indicated great value in their use (Shymansky, et al., 1990). Development of science study began in the early 1960s at Harvard University, with the involvement of more than 100 scientists and educators. The core thesis behind it was to give students hands-on learning experiences without pushing them toward a particular application. It took a radical approach by encouraging open ended activities for students (Lawlor, 2006). The study found that "things" encourage children to ask questions and find their own answers. Educators such as Hunt, Piaget, Bruner, and Almy capitalized the learning potentials of children. These educators conducted research that illustrated the importance of concrete experiences.

Modern Cognitive Science Perspective of Learning

In constructivism, knowledge does not represent reality. Rather the knowledge represents dynamic coherent organization of individual or group thinking. As phrased by Wikipedia (2006), a metacognitive design or approach monitors a student's memory in two ways: conscious/ factual, and unconscious/ implicit knowledge. In constructivism, the mind is constantly constructing new knowledge from experiences. Implicit knowledge is seen as lifeless. A metacognitive approach to instruction may serve as constructivist-based teaching in two ways: Students must be conscious to take control of their own learning, and the teacher works as a facilitator as students consciously construct new knowledge.

Many instructional strategies exist to help students grasping science content. One instructional strategy, termed as 'bridging', has been successful in helping students overcome persistent misconceptions (Brown, et. al. 1993). The bridging strategy attempts to construct students' beliefs to their misconceptions through a series of intermediate analogous situations. In order to bridge the gap and anchor conceptions, students must make sense of new ideas in terms of existing ones. In doing so, they achieve meaningful learning. Meaningful learning results in knowledge that students can apply to novel situations. This type of learning is contrasted with rote memorized learning in which students' grasping of the subject is limited to classroom contexts and is often of short duration. Learning may be influenced in fundamental ways by the situation in which it takes place. Often, a community-centered approach requires the expansion of norms for the classroom and school and connections to the outside world that support core learning values (Bransford et al, 2000).

Teaching and learning are interactive processes in which both the teacher and the student need opportunities to talk through and check out developing understandings. Students need help changing their ideas about a concept in ways that make sense to them. This change can only be achieved by helping the student construct a new and deeper understanding of the concept. According to Linn (2000), the ideas of science are often counter to our intuition of common sense. Unguided experiences with natural interpretations of phenomena can result in misunderstandings. Teaching for meaningful learning takes time. For this reason, the pressure to cover the entire curriculum may result in little comprehension on the part of the students. According to Danielson (1996), it is better to understand a few key concepts than to memorize pages of facts without in-depth understanding.

Unintended learning outcomes occur when students construct understandings that diverge from the teacher's instructional goals. A demonstration or explanation that seems clear to the teacher can take on entirely different meanings in the eyes of the students.

Students who have not achieved meaningful learning often incorporate the language and forms of a lesson into their old ideas without making a fundamental change in their old frameworks (Annenberg Media, 2006). Since each student constructs knowledge in her or his own unique way, fitting new ideas among the old, only the student can take accountability for her or his own learning. However, teachers can lead, coach, advice, and provide rich learning opportunities (Annenberg Media, 2006).

Constructivist Perspective in Science Education

According to Mintzes and Wandersee (1998), the history of science education is often categorized by large-scale shifts and emphasizes in curricular and instructional practices. They stated that science history is full of many examples of debates concerning reality and the nature of science. From a constructivist perspective, science is not the search for truth. It is a process that assists us to make sense of our experiential world. Using a constructivist perspective, teaching science becomes more like the science that scientists do. It is an active, social process of making sense of experiences, as opposed to what we now call school science. Actively engaging students in science is the goal of most science education reform. Tobin (1997) embraced this goal as an admirable one and advocated that using constructivism as a referent can assist in reaching that goal.

Constructivism is a theory of what knowing is and how students come to know. Many constructivists believe that the learner creates his or her own knowledge, and the teacher is simply a facilitator. Teachers working with their students as facilitators provide an excellent framework for improving science education (Bambach, 2000). With the teacher as the facilitator, students enter a classroom with their own experiences and prior knowledge. The teacher's job is to create an environment in which the student can actually explore the content. In a constructivist classroom, the role of the teacher is to organize the information and concepts using a variety of strategies such as: questioning, examining, engagement, exploring, and developing new insights. In addition to these strategies the teacher needs to break down concepts, and allow students to answer their own questions, conduct their own experiments, analyze their own results individually or in a group setting, and come with their own conclusions. In the past few decades, science educators have shown a rapid movement towards constructivism. Results from a study published showed that the past few decades have not been kind to the behaviorist school (Robins et al., 1998). Several studies support the idea that constructivism works best in fact-based problem-solving learning. Teachers have praised constructivism for its pedagogical design. Educational theorists and researchers are constantly examining constructivist based instructional methods primarily in the context of teaching cognitive content.

Based on the different views of behaviorists, cognitivists and constructivists; their perspectives in science, best practices, classroom use and style of learning can be tabularized as

Table 2.1

Comparative Views of Behaviorists, Cognitivists and Constructivists

Areas of measure	Behaviorists	Cognitivists	Constructivists
Perspectives in science	Structured setting of learning strategies and sheltered instructional protocols	Curriculum based on cognitive development of learners in scope and sequence	Flexibility in curriculum, contextualization of learning, and learning by doing

Best practice	Memorization of learning	Assessment of learning based on psychomotor, affective and cognitive domains	Learner's leading role of constructing knowledge
Classroom use	The traditional use of class room setting	Learning resources based on cognitive development of learner	Learner centered/friendly learning

From the science perspective, the behaviorists' view of the structured setting of learning strategies and sheltered instructional protocols are useful for constructivist perspectives of science learning. Curriculum based on cognitive development of learners in case of scope and sequence as cognitivists follow, is the base for the constructivist practice of science learning. Flexibility in curriculum, contextualization of learning, and learning by doing from the constructivists' claim can be tied with the behavioral and cognitive ground for learning science. Similarly, the best practices of learning from the behaviorism as the memorization of learning, assessment of learning based on psychomotor, affective and cognitive domains from cognitivists' view can be integrated with constructivists' view of learner led learning. On the other hand most of the classrooms are behaviorist dominant and learning resources are prepared based on the cognitive development of learners. It is necessary to understand these practices to reform the classroom settings to create CLE.

In summary, constructivism can serve as a philosophy and a referent for science teaching (Lorsbach & Tobin, 1992). Although constructivism is an epistemology, it can also be understood as a theory of learning. Students actively construct knowledge in the process of learning through interactions with phenomena.

They build up meaning of the phenomenon through interactions within a social framework (Greer & Rudge, 2003). Although the epistemological positions of constructivist theory are often challenged by philosophers and scientists, researchers generally agree that students learn by making sense of phenomena as they experience them, evaluate their qualities, and attempt to make sense of them within a socially acceptable context in light of prior knowledge (Linn, 2000).

Best Practices of Science Learning

An overlap exists regarding constructivism and best practices of science learning. According to Fathman et. al. (1992), science activities can provide meaning-making experiences for students learning science in second language. In order for new knowledge to be acquired in science and in language, it must be an active meaning-making process. Students must make sense of it or they may seem lost. The science classroom can provide an excellent atmosphere for developing the social behaviors that students need in order to find solutions to local and global science problems. Science is often seen as a tool for communicating meanings and solutions. For students learning English as a second language, new science concepts can create difficult problems. Their prior knowledge may conflict with the information to be learned. Concrete experiences facilitate the construction of appropriate conceptual structures. Science investigations actively involve students in carrying out the processes of science by moving from observing to hypothesizing and interpreting results. Objects and living things that can be touched and manipulated help in making the connections between words and meanings that are needed for understanding. Piaget (1972) argued that all young children need concrete experiences in constructing new knowledge. Moreover, Piaget (1972) outlined numerous principles for constructing cognitive structures. During all development stages, children experience their environment using mental maps they have constructed. If a child's experience is a repeated one, it fits easily into their cognitive structure. Piaget (1972) argued that different and new experiences cause the child to lose equilibrium and alter their cognitive structure to accommodate new situations.

According to Sexton (1996), if students are to learn to think critically, analyze information, make sound arguments, communicate scientific ideas, and work as part of a group, they need to apply ideas learned in one context to new and realistic situations. The students need opportunities to apply the processes of science so that science comes to be understood, not as a set of facts to be memorized, but as a method for understanding themselves and the world around them. Learning to negotiate meaning, through interaction with others, requires exposure to many genuine real-life communicative situations. Feedback is more than just giving correct answers (Zehler, 1994). Feedback means guiding students in analytical thinking processes and providing suggestions for alternative ways of thinking. Feedback must come at a time when students are attentive and engaged so that they can reflect, make adjustments, and try again. Error correction for its own sake has little value, but given in an appropriate manner and at a time when the learner is ready. It can trigger the necessary conceptual and language modifications. Interestingly, peer feedback is often more powerful than that is given by the teacher (Zehler, 1994).

Good instruction does not necessarily lead to student understanding. Krashen (1987) emphasized that the quality of understanding, rather than the quantity of information presented, is important for successful science learning. Selecting only the most important concepts and skills to teach enhances the quality of learning. The quantity of concepts presented needs to be kept at a level that facilitates language development. For Piaget (1972), this means developmentally appropriate. He maintained that educators need to plan developmentally appropriate curriculum that enhances student logic and cognitive growth. He argued that teachers need to emphasize the importance of student interactions with the surrounding environment, and the role that fundamental concepts play in establishing cognitive structures. According to North (1997) science instruction can be meaningful for students if appropriate strategies are used to make instruction comprehensible. The science content should not be simplified, but the method of delivery should be adjusted to provide students with ample opportunity for participation, thereby making the concepts comprehensible.

Preferring Learning Styles in Learning Science

The rationale for conducting the literature review presented, in this section of learning style preferences, is to create a framework within which to determine, establish and identify the learning style preferences of the secondary level science learners. The framework accommodates them in the design and development of the interactive science learning materials using Kolb's Learning Style Inventory. Based on the experiential learning, Kolb's Learning Style Inventory (KLSI) is useful for the benefit of learners in a constructivist learning environment. Individualized presentation and order of delivery depends on learning style. Most learning style elements can be accommodated into the learning preference by developing learners' awareness of their own styles, permitting some flexibility and then gradually developing the types of resources that complement learning styles (Dreyer &Van der Walt, 1996). Learning style research has been identified as an extremely important element in the improvement of the teaching and learning process in education (Tarmizi & Baker, 2006). DeBello (1985) identified the relationships between academic achievement and individual learning style consistently with the features.

Jester and Miller (2000) stated that there is no such a thing as a good or bad learning style. Success comes with many different learning styles. A key to actively involving learners in learning lies in the understanding of learning style preference (Agogino & His,1995). Reiff (1996) claimed that styles influence how learners learn, how teachers teach, and how both interact. Further each person is born with certain preferences towards particular styles, but these preferences are influenced by culture, experience and development. Keefe (1987) asserted that perceptual style is a matter of learner's choice, but that preference develops subconsciously. A teacher alerted to these preferences can arrange for flexibility in the learning environment. Silver, Strong and Perini (1997), however, argued that learning styles are not fixed throughout the life, but develop as a person learns and grows.

Literature shows that many theories on learning styles exist and that there are wide varieties of definitions of learning styles. There is no single way to describe the construct of learning styles. Learning styles are one of the many kinds of individual differences, which affect learning. The age, aptitude, general intelligence, modality preferences (visual, auditory or kinesthetic), motivation, and socio-cultural factors are other important variables (Skehan, 1989). Jester and Miller (2000) stated that learning styles refer to the ways an individual learner learns best. Learning styles are the composite of characteristics of cognitive, affective and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment (Bennet, 1990). Raleigh (1999) stated that learning style denotes the typical ways in which a person takes in and processes information, makes decisions, and forms values. A person's style is reflected in her or his behavior. Dunn, Denig and Lovelace (2001) defined learning style as the way in which each person begins to concentrate on, process, internalize, and remember new and difficult academic content. Learning style is the way a person acquires knowledge. It is not what a person learns, but how a person learns (Smarterkids Education Center, 2001).

I believed that learning style is a habitual way or preference of an individual. It is used to acquire and retain new information with understanding in order to be able to transfer or reproduce it in a given situational context within one's experiential world. Regardless of the definition used, the construct of learning styles is believed to be a relatively stable trait that characterizes the way a person prefers to learn (Davidson, Savenye & Orr, 1992).

Different theorists have developed different learning style models. Learning style models are built on an assumption that each individual has a unique set of biological and developmental characteristics. These unique characteristics impact substantially on how a person learns new information and skills.

Table 2.2

Learning Style Models

Learning Styles Models	Pragmatics	Actives	Holistic	Analytical
Keirsey Temperament Sorter II	Guardians	Idealists	Artisans	Rational
Kolb Model	Converger	Accomodator	Diverger	Assimilator
Hermann Brain Dominance	Sequential	Emotional	Holistic	Logical
Visual, Auditory, Kinesthetic model	Reading/ writing	Verbal/auditory	Visual & global learners	Kinesthetic learning
The Gregorc Model	Concrete sequential	Concrete random	Abstract random	Abstract Sequential

The 4MAT Model	Analytic Learners	Innovative	Dynamic Learners	Common Sense Learners
The Honey-Mumford Model	Pragmatists	Activists	Theorists	Reflectors
Felder and Silverman Learning Style Model	Sensing	Verbal and Global	Visual Intuitive Global	Global Intuitive

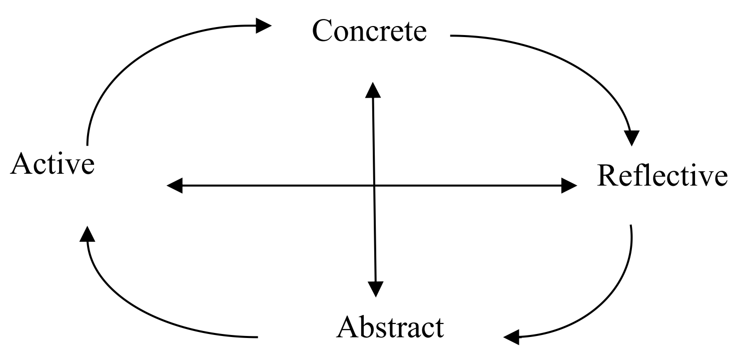
The belief that individual learners learn differently is well established in the literature (Good & Brophy, 1986). If the learning situation is organized in a manner that takes advantage of the individual's learning strengths, the rate and quality of learning improve the learning Styles. Table 2.2 illustrates the eight learning style models or theories with their comparative parameters. Among these models, Kolb's Learning Style Model had been chosen as the theoretical point of departure of this research study in identifying the learning styles of the secondary level science students.

Kolb's Learning Styles Model

Kolb's Experiential Learning Model (KELM) is a well established model that has attracted much interest and application (Chi-Ching & Noi, 1994). Learning is conceived as a four-stage cycle starting with concrete experience which forms the basis for observation and reflection upon experience. The learning model builds on the learning theories of Dewey, Lewin and Piaget, and takes it into account of experience, perception, cognition and behavior as the critical elements in the learning process (Kolb, 1984). The Philosophy of the Kolb's model is that knowledge results from the combination of two dimensions: grasping information or perceiving, and transforming information or processing. Kolb's experiential learning model and learning style inventory (KLSI) were used to determine and establish the learning styles of the secondary level science students. The next section offers a contextual representation of the principle components of the model.

According to Jarvis (1995), the experiential learning is actually about learning from primary experience. That is learning through the senses. Experiential learning may be defined as knowledge, skills, and/ or abilities attained through observation, simulation, and/ or participation. It provides depth and meaning to learning by engaging the mind and /or body through activity, reflection, and application. Kolb (1984) defined experiential learning as the process whereby knowledge is constructed by the transformation of experience. Knowledge results from the combination of grasping and transforming experience. The Kolb model focused on how learners most readily perceive the information to be learned, and how they prefer to process that information. The figure 2.10 represents the four stages of experiential learning cycle.

Figure 2.10: Four Stages of Experiential Learning Cycle (Kolb, 1984)



According to the four stages learning cycle, concrete experiences are the basis for observations and reflections. These reflections are assimilated and distilled into abstract concepts from which new implications for action can be drawn. These propositions can be actively tested and serve as guides in creating new experiences

(Kolb, Boyatzis, & Mainemelis, 1999). Concrete experience (CE) is a stage, an individual carries out a particular action and then observes its effect. Experiencing or immersing oneself in the doing of a task is the stage in which the learner simply carries out the task assigned. The engaged person is usually not reflecting on the task at this time but rather just carrying it out with intention.

The next phase is reflective observation (RO). Reflection involves stepping back from task involvement and reviewing what has been done and experienced. The skills of attending, noticing differences, and applying terms help identify fine events. One's paradigm (values, attitudes, and beliefs) influences whether one can differentiate certain events. Understanding the effects of an action in a particular instance is required in order to anticipate what would follow from the action if it were to be taken again under the same circumstances. After RO, the learner moves into a phase of abstract conceptualization (AC). This involves interpreting the events that have been noticed, and understanding the relationships among them. It is at this stage that theory may be particularly helpful as a template for framing and explaining events. This is the stage where learners build structures of explanations for themselves about the way the world works. Learners develop theories, or rules to define their expectations and the cause-effect chain. The last stage of Kolb's experiential learning cycle is active experimentation (AE). This is the application of the new knowledge, through action, in new circumstances within the range of generalization. Here planning takes the new understanding and translates it into predictions about what is likely to happen next, or what actions should be taken to refine the way the task is handled.

In reality, learners begin at different points of the cycle and may or may not progress in a systematic manner (Kolb, 1999). The four learning styles, or modes, of

Kolb are also paired into two continua: Concrete Experience (CE) versus Abstract Conceptualization (AC) and Reflective Observation (RO) versus Active Experimentation (AE). The latter pair primarily reflects the differences between inductive and deductive learning. For a complete learning experience to take place, Kolb believed that learners must complete all four of the learning stages. Although everyone utilizes each of the four learning styles to some extent, each individual has preferred learning styles. Kolb's learning style inventory has been used widely and is well represented in the literature (Healey & Jenkins, 2000).

According to Kolb's theory, the accommodator (activist) combines active experimentation and concrete experience. Accommodators or activists tend to be people oriented and learn through trial and error on problem solving. Their strength lies in doing things and involving themselves in new experiences. They are characterized by creative experience and active experimentation (Clark, 2000). People with this style have the ability to learn from hands on experience, carrying out plans and involving themselves in new and challenging experiences (Kolb, 1987). The diverger (reflector) is also a person who acts upon concrete experience but in combination with reflective-observation. Divergers or reflectors tend to use information from their senses and feelings, and view a situation from different perspectives, relying heavily upon brainstorming and generation of alternative ideas (Clark, 2000). People with this learning style are best at viewing or reflecting on concrete situations from different points of view. This approach to a situation is to observe rather than to take action (Kolb, 1984). An assimilator (theorist) is the person who combines reflective observation and abstract conceptualization. Assimilators or theorists are characterized by abstract thinking and a theoretical orientation (Kolb, 1987). O' Connor (1997) stated that assimilators grip experience abstractly at first, transforming through reflective observation. People with this learning style are best at understanding a wide range of information and putting it into concise logical form (Kolb, 1987). The last of Kolb's learning styles is the converger (pragmatist) – a person who combines abstract conceptualization and active experimentation. They tend to have an understanding of practical ideas and their applications. A converger is classified as someone who wants to solve problems and who relies heavily upon hypothetical deduction focusing on specific problems. People with this learning style are best at finding practical uses for ideas and theories. They have the ability to solve problems and make decision (Kolb, 1987). According to Raschick et al (1988), these quadrants enable the researcher to combine an individual's four separate dimensions into one composite classification. This is done by comparing a person's scores on the two axes: CE-AC and AE-RO.

Implication of Learning Style Preferences in Learning Design

Research on accommodating learning styles into the design of the instructional learning material for the classroom indicates that the learning designers tend to incorporate research on learning styles to inform the design of learning material (McLoughlin, 1999). These results, in learners' feeling, empower them when learning materials match their needs, and their sense of personal achievement increases as the level of self-direction rises (Dwear, 1996). In order for learning to be effective in achieving desired outcomes, educators need to be aware and understand individuals' learning styles, matching them with learning resources. Ebelin (2001) contended that there is no one-size-fits-all plan for teaching and learning. It is the responsibility of the teacher/ facilitator to customize instruction by adapting the basic plan with a particular learner in mind.

MacKinnon (1998) warned that:

> The wide range of individual differences meant that there is no single method for nurturing creativity. Ideally, the experiences we provide should be tailor-made, if not for individual learners, at least for different kinds of learners. We should remember that the same fire that melts butter hardens the egg (pp103).

A typical classroom is a group of learners with a multitude of learning styles and a wide variety of experience being taught by an instructor who has his or her own teaching style. According to Felder (1993), learners, whose learning styles are compatible with the teaching style of the course instructor, tend to retain information longer. They apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/ teaching style mismatches. Individualizing instruction to match learning style preferences improves learners' academic achievement and attitude towards learning (Dunn et al, 1995). Sternberg (1994) explained that style is a preferred way of using one's abilities. It is not itself ability, but rather a preference. For educators to be successful, Sternberg believed that they must systematically vary teaching and assessment methods to reach all the different thinking and learning styles of learners. Sarasin (1998) maintained that instructors should be willing to change their teaching strategies and techniques based on an appreciation of the variety of learner's learning styles. They should try to ensure that their methods, materials and resources fit the way in which their learners learn and maximize the learning potential.

Carbo and Hodges (1988) stated that matching learners' learning styles with appropriate learning strategies improves their ability to concentrate and learn. If mismatching occurs, learners feel anxious and even physically ill when trying to learn (Taylor, 1997). Most teachers are best at teaching children who match their own styles of thinking and learning, and learners tend to achieve higher grades when their styles are same as those of their teacher. If this is true, teachers must be flexible and exhibit different styles in their classroom (Sternberg, 1994). Knowledge of learner's learning preferences can aid instructors in preparing class, designing class delivery methods, choosing appropriate technologies, and developing sensitivity to different learner's learning preferences (Diaz & Cartnal, 1999). Curtis and Winsor (1993) contended that the adult learner generally is more culturally diverse and often presents a diversity of learning styles. The Board of Trustees of the University of Illinois (2001) stated that as learners have different learning styles or combination of styles, educators should design activities that address their modes of learning in order to provide significant experience for each class of participants. Dangwal and Mitra (1998) confirmed that accommodation of learning styles can result improved attitudes toward learning, and an increase in productivity, academic achievement and creativity. These authors further confirmed that the most effective learning occurs when the learning activities most closely match the learners' preferred style.

Mariani (1996) asserted that educators could offer learners a variety of learning opportunities to match the range of styles presented in the classroom, through varying material and activities, grouping learners with different learning styles or allocating different tasks to each group. This matches the tasks to the learners. On the other hand, educators can also help to shape or adjust their learning approach to suit the requirements of the tasks, helping the learners to use something other than their preferred style, thus encouraging flexibility and versatility. In a sense, this is a case of matching the learners to the tasks. Rossi-Le (1995) pointed out that if learners come from a background where education is heavily teacher-directed, knowledge of their individual learning style preferences could help them to assume responsibility for their own learning by helping them select learning strategies that built on their innate preferences. All learners should have ample opportunity to learn through their preferred styles. They also need to be open to the idea of style-flex, that is, learners should be encouraged to diversify their style preferences (Wallace & Oxford, 1992). Ford and Chen (2001) added that matching learning styles with instructional presentation strategies may have important potential in enhancing learners' learning. The main focus of instructional design should be the interaction between learner characteristics, or learning styles, and the design of the learning material (Anderson, 2001). It is evident from the literature that if instructors adjust their practices to accommodate the learners' preferred learning styles in the learning materials, there is an improvement in learners' academic performance/ achievement (Ford & Chen, 2001).

Evidences from Contemporary Related Research Studies

Recent research studies have demonstrated that the constructivist approach to science learning produces more positive effects than the traditional approaches. Their results have suggested that constructivist learning models produce significant gains over traditional instruction in learners' understanding of concepts and principles of science. This section overviewed the current related research studies focusing on constructivist classroom learning design, constructivist learning environment with technology, and impact study of constructivist learning design with special reference to science learning.

Constructivism and Classroom Learning Design

Power (1997), in a doctoral study, identified a theme of the study: Constructivism Defined and Implications for Classroom Solving in Technology Education. The thesis focused on establishing a historical perspective on the theory of constructivism, and tried to explain the implications of constructivism on the classroom including the teacher, student and curriculum. The researcher felt, throughout the discussion of constructivism, the need of study looking on what this means for a classroom. The study demanded the considerable work to be done on improving the education system. Various levels of government within the school system have recognized the importance of this reform movement. Students, parents and the general public have in recent years raised a stronger voice. The research has brought the argument that the ever changing society where we live in, the education needs to be reformed and the theory of constructivism can be the basis of that reform. The researcher claimed that constructivist notions significantly impact on the area of educational research. As a result, teachers themselves become researchers in their own field. With a movement towards constructivist ideals, at least in mathematics and technology education, researchers have to be constantly studying the overall effects of shift in educational arena. Applying qualitative methodological approach, he stressed that the most dynamic field with our education system is technology education and the strong theoretical basis of technology education is constructivism. The research demanded that teachers must play a critical role in the change process as the students and parents. The study concluded that a collective effort toward reform must be made if it is to become a reality. However, I have felt that there is need of further study about the learning style preference to tie up with the technology to follow the constructivist learning approach in teaching learning activities.

In a doctoral research study, Paparozzi (1998) stressed the necessary pairing of instructional planning and learning theory. The study was entitled as Implementing Constructivism in the Middle School Classroom. This study defined the components of a middle school history curriculum based on a theory of learning consistent with the use of cognitive tools and the constructivism. The study considered the following elements of constructivism:

a. Student Centered,
b. Problem Solving,
c. Interpreting and Elaborating Learners,
d. Learners Recognized as Having Prior Knowledge,
e. Interacting Socially and in the Environment, and
f. Errors as Opportunities (pp 47).

Utilizing a comparative analysis of learning theories encompassing developmental and constructivist beliefs and their influence on appropriate instructional design, the research addressed the necessary pairing of instructional planning and learning theory. Additionally, an examination of linguistic tools and their relationship to cultural development and distinctive kinds of comprehension, as well as specifics of the various learning stages, preferences, and skills were used to provide a rationale. This analysis was employed in the development of a middle school history/social studies curriculum premised upon the ideology that students employ intellectual tools at different stages of maturation that support specific types of understanding. The resulting instructional design for students, grade six through eight, contained the fundamental elements of constructivism, how these elements manifest themselves in a curriculum, appropriate activities, projects, and methods for evaluation. The study claimed that the manifestation of Constructivism in the Curriculum should be integrated curriculum, entering into the consensual domain, not pre-specified curriculum, understanding multiple perspectives, cognitive flexibility, apprenticeship, real world scenarios, and evaluation as a process of explanation, performance, and effective planning. The researcher claimed that, in this new paradigm for education, the role of the teacher transforms from expert and authority figure to partner, mentor, or model. Teachers become assistants in the learning process. By appealing to cognitive strengths and accepting that students bring valuable insight to the school environment, educators might be perceived by students as truly those who are there to help as opposed to those who point out shortcomings. Instead of receiving information and having the retention of facts as a goal, students must actively engage in the production of knowledge through construction, discourse, and reorganization. Students participate in the process and evaluation of their learning, directing and cooperating in classroom tasks and management. The researcher further argued that a crucial change in the realm of information deals with subject matter and the environment. Subject matter is chosen for its relevance in the various stages of development. Educators call upon students to relate to information that they are inclined to be interested. The more the school environment mirrors the real world scenario, the better transfer exists as a goal of constructivism. Another relationship that is transformed exists between students and the process of learning. The researcher claimed that constructivism supports the premise that mistakes done by themselves are not bad, rather they are an opportunity to learn. The construction, planning, and reorganization of thoughts and knowledge constitute learning. The relationship between evaluation and students takes on real world authenticity with constructivism. While constructivism is well known as a theory of how we come to know, little has been done to document it as a theory of teaching (Jonesson, 1992). The researcher demanded to find the answer of the questions of the school systems that have adopted constructivism: what problematic situations have they encountered? Are these districts experiencing similar difficulties? Do the problems stem from educators, parents, administrators, or the students? How have these systems gone about training their teachers and administrators. What research is necessary to determine the best way to foster in constructivism? The study concluded in a discussion concerning the implications of coupling constructivist theory with linguistic strengths, and the impact this union has on curriculum design. Once there is an understanding of the perceptions concerning constructivism coupled with the use of cognitive linguistic tools to assist in instruction, programs need to be developed that specifically address common concerns, misconceptions, and gaps in understanding. The researcher suggested that additional research is necessary to have a full understanding of how school personnel, parents, and students feel about a proposed change in curriculum. Further research and development should occur in the area of instructional design, calling upon constructivism and cognitive tools theory to bridge the space that exists for students who are introduced to these ideas for the first time in secondary education.

Wiley (2000) prepared a doctoral thesis entitled -Learning Object Design and Sequencing Theory. The researcher followed Reigeluth's (1999) definition of design theories as the describing methods of instruction and the situations. This study reviewed, synthesized, and combined four existing instructional design theories, namely Elaboration theory (Reigeluth, 1999), Work Model Synthesis (Gibbons, et al, 1995), Domain Theory (Bunderson, Newby, &Wiley, 2000), and the Four Component Instructional Desing model (Van Merrienboer, 1997) with new work. The result was a new instructional theory: Learning Object Design and Sequencing Theory (LODAS). LODAS provided guidelines for the analysis and synthesis of an undifferentiated content area (e.g. English), the application of which produced specifications for scope and sequence of learning objects. Currently, any person or organization who desire to employ learning objects in their instructional design is required to create their own taxonomy of learning objects. The author considered this to be a major cause of the current lack of practical applications of learning objects. However, taking the taxonomy and learning object design guidelines presented in LODAS, an instructional designer may be able to connect these to the instructional design theory of their choice. It is a considerably simpler exercise than the creation of a new taxonomy. As the theory has been tested, this development has the potential to speed the practical adoption of the learning object approach. It further allowed the simplified application of any instructional design theory to the learning object approach, and provided a common ground for future research in the instructional technology called learning objects. The study was focused on concerning the likelihood of the broad development of learning objects-based technology. The study warned about the dangers of employing technology in an instructionally unprincipled manner. The researcher also felt the need for an instructional design theory providing explicit support for the instructional design and use of learning objects.

Upadhaya (2001) prepared a doctoral thesis entitled –Effect of Constructivism on Mathematics Achievement of Grade V Students in Nepal. The researcher followed three bases of constructivism viz. psychological, philosophical and anthropological. This study was primarily the quantitative study of the grade V students' achievement in mathematics classrooms in community and private schools. The main purpose of the study was to se the effect of constructivism on students' achievement in mathematics with respect to overall performance of students. The study showed that there were significant differences on the control group and intervening group on achievement of mathematics learning and constructivist teaching supported for the better achievement. The researcher also felt the need for an integration of psychological aspect including action and reflection with philosophical aspect including viability and autonomy as well as with anthropological aspect including scaffolding and ethnography. The psychological aspect involved accurate mental construction of reality, coherent experiential reality in philosophical aspect. The anthropological aspect emphasized socially constructed reality.

Villers (2002) contributed to inquiry into learning theory by an in depth study of the elements of constructivism. It also investigated the elements that function in different contexts and contents. In this doctoral thesis entitled as, The Dynamics of Theory and Practice in Instructional Systems Design, the researcher emphasized to integrate different learning approaches. The researcher applied theoretical textural filtration and mixed method case study strategies for the study. Using meta-analysis and a process of criterion-based filtration of textual information, a framework was generated, the hexa-C metamodel- a model of models. The metamodel was relevant to a variety of instructional systems, resources and artifacts, interactive learning environments, and open ended learning experiences. Case studies were undertaken in which the metamodel was applied to three technology – related learning events: a computer-based practice environment, an internet course, and a field work project using computers as tools. The study contributed to the inquiry into learning and instructional theories by undertaking an in depth study of the elements of the integrated framework itself, investigating the ways in which they function in different contexts and contents. This thesis has described the dynamics of theory and practice in instructional systems designed by using it as a tool. This study put forward a dynamic integration of contemporary learning theories and the practice of instructional design. The proposed framework- encompassing the theoretical concepts of constructivism, cognitive learning and knowledge/ skills components, as well as the practical characteristics of creativity, customization, and collaborative learning – can make a contribution to instructional practice and can support for effective learning.

It has also contributed to the inquiry into the nature of learning and instruction. These studies, discussed here, demanded the incorporation of different dimensions of the learning design with respect to technology while applying constructivist learning design strategies. The next section focused on the recent study on designing learning environment and influence of technological backup.

Designing CLE with Technological Backup

Law (2003) dealing with the characteristics of experiential education outlined a synergy between experiential education and environmental education. The researcher in his doctoral thesis entitled: Experiential Education as a Best Practice Pedagogy for Environmental Education in Teacher Education, dealt with the characteristics of experiential education. Through the qualitative case studies, the study outlined a synergy between experiential education and environmental education. The research resulted the way of experiential education as an appropriate pedagogy for meeting the aims and objectives of environment education in teacher education. It has further identified possibilities and limitations of experiential education in teacher education. This thesis has challenged the teacher directed practices by identifying new roles for the teacher, the need for reflective practice and use of experiential education as a set of relationships that focuses on constructivist approaches. The research further demanded the need of research to incorporate the experiential learning style preferences while learning science.

Nix (2003) evaluated a new integrated science learning environment (ISLE) that bridged gap between the traditionally separate classroom, field trip and information technology milieus. His doctoral thesis, entitled: Virtual Fieldtrips: Using Information Technology to Create and Integrated Science Learning Environment, had followed the mixed method strategies during the case studies. The model involved, here, was a multifaceted design to address the three basic forms of learning: acquisition of knowledge, change in emotions or feelings, and gain in physical or motor actions or performance. A holistic approach to teaching encompassed a step wise cumulative strategy. The study reinforced all scales of the constructivist learning environment survey (Personal relevance, uncertainty of science, shared control, critical voice, and student negotiation). It minimized the detrimental effects of information overloaded and non-linear processing. By addressing individuals and recognizing limitations, the same conceptual and logistical frameworks were applied to teachers and to students uniformly in the classroom and in the field. According to the researcher, the final product of the ISLE program was constructed by linking the elements common to the supporting learning environments (university classroom, field trip, and information technology) at their basic levels: newness, massiveness, and appropriateness. A combination of qualitative methods and quantitative measures provided insight into the field trip milieu and evaluation of the near and far term effects of exposure to constructivist pedagogy answering the general question of whether changing teachers' learning environments might affect a change in their respective students' learning environments. Three new versions of CLES were shown to be valid and useful in secondary schools. Administration of these versions (CLES – CS: Comparative Student, CLES – CT: Comparative Teacher and CLES – A: Adult) of the same instruments was used to characterize the learning environment of ISLE in public private school classrooms from a practical point of view. This study documented a new model for improving learning and understanding in the field of education, specifically in science education. This study further verified and strongly supported the influence of CLES in learning science. I also incorporated the elements of CLES while developing conceptual and theoretical model for the study. The real world is where theory and practice come together and science becomes relevant, making sense that leads to understanding. The conceptual and logistical frameworks of the ISLE model seamlessly merged theory and practice with science and education through effective applications of information technology. It was mainly to create a rich learning environment. Virtual fieldtrips based on the ISLE model can enable the principles of student centered inquiry and constructivism to be practiced for the benefit of all styles and ages of lifelong learners. The researcher claimed that this key factor of the ISLE program broadened all participants' horizons and enabled them to see their role within the system. The common elements (knowledge) and basic components (understanding) in each realm became evident and the power of transfer for both content and concept was realized.

Youngs (2003) aimed to investigate the feasibility of creating a constructivist learning environment in a university mathematics course as an alternative to the dominant transmissionist learning environments currently in place in most of the courses. The study sought to ascertain which dimensions of a constructivist learning environment, the university students preferred and how these preferences changed after being in such an environment. The dimensions incorporated were: autonomy, prior knowledge, negotiation, and student centeredness. The study followed qualitative ethnographic approach. The cases were analyzed thoroughly and the author documented the result in his doctoral thesis entitled: Creating a Constructivist Learning Environment in a University Mathematics Classroom. As an instructor in the study, the researcher found it necessary to change a number of his prior practices as he sought to implement a constructivist learning environment. The researcher's teaching practice was transformed as he sought to become a facilitator and empowerer of students' mathematical knowledge constructions instead of a transmitter of mathematical content. The results of the study indicated that it was fairly easy to implement the autonomy, prior-knowledge, and negotiation dimensions of a constructivist learning environment, but difficult to implement the student-centeredness. However, students' preferences closely matched the learning environment with its weak student-centeredness dimension. The results of the study showed that most students very strongly preferred the autonomy dimension, and weakly to moderately preferred the student-centeredness. According to the researcher, the data indicated that during the study student preferences for prior knowledge and negotiation increased slightly, preferences for student centeredness increased moderately, and preferences for autonomy increased significantly. The study claimed that the four dimensions were not implemented equally. The first three dimensions were significantly implemented, but the student centeredness dimension with less emphasis. The learning environment, the students perceived, were in place closely matched their preferences.

Applying qualitative approach in doctoral research study entitled: Creating Pedagogy of the Unique through a Web of Betweeness, Farren (2005) examined the growth of her educational knowledge and development of her practice, as higher education educator, over six years of self-study. The thesis reported the evolution of her educational influence in her own learning, the learning of others and in the education of social formations. The context of her research was the collaborative process that developed between her and participants. Within the context, she worked with a sense of research-based professionalism, seeking to improve her practice through the use of living educational theory approach that sustained her in asking, researching and answering the question how she improved her practice. She claimed that the values of the research have been transformed into living standards of judgment. The value included web of betweeness and pedagogy of the unique. According to the author, the web of betweeness refers to how we learn in relation to one another and also how information communication and technology (ICT) can enable us to get closer to communicating the meanings of our embodied values. Similarly, pedagogy of the unique respects the unique constellation of values and standards of judgment that each practitioner, the researcher, contributes to a knowledge based on practice. She concluded that individuals' collaborative self-studies contribute to the development of sustainable global educational networks of communications.

Liu (2005) in her doctoral thesis focused on designing learning objects to support constructivist learning Environments. Her design demonstrated a possibility of using constructivist learning theory to guide the design of learning objects so that constructivism and objectivism can be integrated together. Through her design, the cooperation among learning object became possible and easy, and thus learners can also actively participate in the construction of learning objects. Learning objects are rendered by some patterns and the learner can further configure the course and have the material adapted to her needs at run time. The researcher provided a way to allow the learner to grasp the whole picture of the course in the fastest way by taking control of the learning and by the support of the system. Such ease to view the learning material, iteratively in different ways, greatly assisted learners to learn efficiently in the real constructivist learning environment. Such a direction was the future of learning object research. Designing learning objects seemed a very struggling but enjoyable experience for the researcher. As there were a lot of development and specification of learning objects, the researcher was not aware of any design and implementation that demonstrated a significantly improved learning experience and met the expectation of learning objects. As the concept of learning object is certainly very attractive and consistent with many people's view of knowledge and learning experience, to probe deeply into such a concept and to experiment with it provided her more experience and insights into many facets of this issue. Constructivism, as the latest learning theory, was rarely adopted in the design of learning objects. Realizing the insufficient research on learning objects in association with learning theory, ideal learning object design was more explorative in nature, to demonstrate the possibility of applying constructivism to learning object design. The study claimed that with the increase of breadth and depth of learning material, the system's advantage becomes more obvious in facilitating the learner to have a better control of the learning material and their pace and strategy of learning. She concluded her thesis by putting learning back into the hands of the learner, the system assists the learner to construct knowledge efficiently in the real constructivist learning environment. As such the author suggested that it is further needed to be verified in case of science learning in constructivist learning environment.

Chieu (2005), with the aim of designing truly constructivist and adaptive learning systems based on cognitive flexibility, conducted a doctoral research. Based on the qualitative methodology, the case studies were investigated. The research was aimed to help designing truly constructivist and adaptive learning systems. The researcher proposed a set of criteria for certain aspects of constructivism and used as guidelines for designing learning systems and for evaluating the conformity of learning systems with the constructivist principles. The researcher in the thesis claimed that *the operational approach proposed makes the design and use of adaptive learning environments supporting cognitive* *flexibility straightforward and effective*. More specifically, the dissertation made four main contributions to the interdisciplinary field of learning and e-learning technology. Firstly, the thesis proposed operational criteria for cognitive flexibility and presented both justifications and examples of their use. The set of criteria may be used in different instructional situations for designing and evaluating conditions of learning. Secondly, on the basis of the criteria for cognitive flexibility, the thesis proposed an operational instructional design process and shows an example of its use. The process may also be applied in a variety of instructional situations for the design and use of learning systems fostering cognitive flexibility. Thirdly, the thesis introduced a new, open-source, domain-independent, Web-based adaptive e-Learning platform, named COFALE, and illustrated an example of its use. The platform may be used for designing adaptive learning systems supporting cognitive flexibility in various domains. And finally, the thesis reported on a preliminary evaluation of the example handled by COFALE with actual learners. The study provided a certain number of encouraging results for fostering cognitive flexibility by means of ICT-based learning conditions. The researcher concluded that the ability to cognitive flexibility restructures one's knowledge in adaptive response to radically changing situational demands. The researcher further claimed that the operational approach proposed made the design and use of adaptive learning environments supportive to cognitive flexibility straightforward. It is effective with e-learning technology.

Katzlberger (2005) confirmed that teaching and interacting with social agents influenced middle school students positively. Applying experimental studies in his doctoral research, the researcher expected that learning by teaching would have a positive influence on learning and motivation of students. He used four measures namely the knowledge test, the near transfer task, the motivated strategies for learning questionnaire, and experiences that energize construction of knowledge. The researcher was interested to find if all students learn and if learning, motivation, and transfer differ between treatment groups. He applied quantitative methodology for the research study. According to the researcher, increased self-efficacy seemed to indicate that students felt more capable of dealing with their mathematical problems if they were asked to teach, than if they were asked to learn from the teacher. Improved self-regulation and critical thinking were a direct consequence of the reflection initiated by the teaching tasks. This confirmed that learning by teaching agent is a powerful tool for providing motivated learning environments that keeps the students interested in their learning and problem-solving task. The author further suggested that future work on this system's design should focus on improving the dialogue interaction with students. Like game environments, students might use buttons or menus to teach the agent or put queries without the tedious task of navigating a dialogue structure. Another interesting result was that the students who learn by teaching agent often focus on the performance of their agent, and less on their own. The existing system tried to balance and interrupt using knowledge for problem solving and teaching it, but there may be better approaches to help improve learning gains. In addition, letting students create tests and quiz questions for the agent may give this approach another boost. From this doctoral study, the researcher concluded that the demonstrated benefits in transfer of learning and motivation might help the approach a worthy target for implementation, commercialization, and for future research. Applying qualitative approach in a doctoral study, Chen (2005) introduced a number of media selection models over the last few decades. These models were designed to assist educators and trainers in selecting the most appropriate media from instructional situation. A common assumption undergoing these models is that instruction is based on a transmission model of learning in which an instructional medium (e.g. computer, teacher, and television) delivers or transmits an instructional message to a teacher. This assumption is often inadequate for educators interested in selecting media for constructivist learning environments. From a constructivist learning perspective, students do not learn from technology but rather with technology. In order to help classroom teachers to make use of computer technology in teaching, a web selection tool was examined about user's performance on required tasks and user's attitude (Preference) towards this tool. In connection to this reality, the researcher claimed that the concept of learning with technology focuses on the intellectual partnership between the learner and the technology. This study confirmed that children do not learn from the technology but learn with the technology. After subsequent analysis of the data, the researcher generated implications for integrating technology into teaching and learning and for the use of the web tool sites. The implications were tied into the belief that effectively integrating mind-tools through the creation of a professional web tool site utilize the web tool in technology integration courses offered to pre-service teachers. It was the researcher's hope that it would be better to investigate whether the differentiation is commonly emerged in a technology integration course and whether there is any implication for improving it.

Busbea (2006), in her doctoral study, entitled: The Effect of Constructivist Learning Environments on Student Learning in an Undergraduate Art Appreciation Course, mentioned the purpose of the study as to determine the effects of constructivist methods on student learning in an undergraduate art appreciation class. The researcher designed the constructivist learning activities and implemented in an undergraduate art appreciation course. Mixed methods approach was employed to study the cases. Through the constructivist learning activities, students were involved in their learning throughout the year in realistic art roles in which they worked as curators, Web page designers, and artists. The researcher interpreted the data and found the subjects. The study demonstrated nine patterns of learning the subjects which included: explaining the processes, applying their knowledge, connecting meanings, interpreting works of art, judging quality, empathizing with artists, viewing in a new way, assessing their learning, and continuing on their own. The data evidenced that constructivism results in a deeper understanding of art than the learners merely as passive recipients of knowledge. This was not only indicated by the patterns of learning which emerged from the data, but also in the students' awareness and regulating of their cognitive processes. The results of this study suggested that art appreciation instructors have an opportunity to facilitate high levels of student thinking and encourage meta-cognitive skills through constructivist methods. The research studies discussed here pointed out the mastery of designing constructivist learning environment based on experiential learning style preferences. The next section illustrates the impact study of constructivist learning design based on the recent research study.

Understanding Science through Different CLD Contexts

Robertson (2006), in his doctoral thesis with a theme of the study as: Teachers Integrating Online Technology in Technical and Further Education (TAFE), focused on the research study of online technology. He was based on Basil Bernstein's pedagogic device, technological determinism and technological instrumentalism, and Rogers' Diffusion of innovation. These principles were used to inform the theorizations of individual's responses to uptake the innovations. He investigated dynamics of learning design that shape TAFE teachers' pedagogic practices when online technology is integrated into their teaching practice. The researcher proposed a model that represented the conditions supporting the uptake of online technology. Based on the case examples of the research participants, Basil Bernstein's pedagogic device informed the development of a model that represented the dynamics of shaping TAFE teacher's pedagogic practices when online technology is integrated into their teaching practice. This study demonstrated the complex nature of the dynamics that shape teacher's pedagogic practices within constructivist epistemology. The research participants preferred and implemented teaching principles that were compared based on teacher control (training) of content, sequence, pace and criteria.

Middleton (2006), in his doctoral thesis, entitled: An Interpretive Journey into Constructivism and Primary Science Curriculum, illustrated that curriculum flexibility is the major concern of constructivist learning. The principle focus of this study was a reflection on the researcher's planning methodology on teachers' planning from 1988 to 2002. The researcher in his doctoral thesis implied qualitative methodology. He examined a variety of papers on constructivism, which disclosed the origin, the popular types, unifying characteristics, principles and their differences, and students and teachers co-constructing constructivist learning environments. The underlying principles of constructivism provided a lens to improve perceived deficiencies in the researcher's classroom. The researcher used two versions of constructivist learning environment survey (CLES) namely actual and preferred. The preferred CLES was given at the start of a unit of work and provided an insight into the implementation of constructivist ideals. The actual CLES was given to the same group of students at the end of the unit to ascertain whether the scales had been achieved from their perspective. The inclusion of the constructivist learning environment CLES assisted in making constructivism visible. A strong purpose therefore evolved from the study as a more effective planning methodology. The researcher found that curriculum innovation had implications on teachers' planning methodology with a strong emphasis on collaborative planning. He further suggested that constructivist epistemology theory enables teachers to use the underlying principles, as a referent for their teaching and learning. As a result of this thesis study, the researcher claimed that he had achieved a greater understanding of the potential of constructivism and the essential learning, which consequently enhanced his planning methodology.

Marton (2007) chose to investigate constructivist theory and to implement constructivist teaching practices within education classroom to determine if constructivist teaching practices would facilitate a shift to a more student centered learning environment. This doctoral study aimed to determine if constructivist strategies positively impact student learning. Following qualitative auto-ethnographic study, a positive impact was observed and thus constructivist strategies may be beneficial to the creation of student centered learning environments. The researcher also suggested that it may assist in broadening student inquiry and investigation with lessons of subjects including science and mathematics as well.

Cernusca (2007) applied mixed methods strategies focusing on the doctoral dissertation entitled: A Design-Based Research Approach to the Implementation and Examination of a Cognitive Flexibility Hypertext in a Large Undergraduate Course. The study had proposed a structure for cognitive flexibility hypertexts that builds on the theoretical model of situated cognition for the development of design metaphors. This structuring of the online learning environment proved to be effective for novice learners, allowing for criss-crossing of the inquiry field from different perspectives, and for a progression of learning task complexity within each of these crossings. This study found that the alignment of the nature of scaffolding and the nature of the task associated with each crossing of the cognitive landscape can increase the overall impact of the environment on the learning outcomes.

Orchard (2007) mentioned that his doctoral study focused on professional development practices that empowered reluctant teachers to implement and sustain improved instructional practices. Constructs were viewed through the perspective of learner-centered principles in order to connect scientifically proven practices for teaching students in the classroom to effective professional development practices for teachers. After exploring the cases, the findings of the research indicated that when schools implement learner-centered professional development practices, student achievement increases and teacher reluctance towards new practices and change decreases. Four themes emerged from the study as the types of professional development that encourage reluctant teachers to sustain new practices are: show them why and how, empower them to safely explore, emphasize their professional contribution, and engage them in meaningful conversations. This study suggested for additional research to better understand the nature of administrator reluctance toward new practices, as well as how the increased leadership capacity for teachers engaged in learner-centered professional development impacts the roles and relationships within the traditional educational hierarchy.

Izquierdo (2008) in his recent doctoral study applied quantitative methods to assess the impact of an Educational Intervention Based on the Constructivist Paradigm on the Development of Entrepreneurial Competencies in University Students. He concluded that the constructivist perspective is the way to go for entrepreneurship education. He further added that current educational practices in science-related areas have constructivism as the new paradigm although this perspective has not been widely applied in the field of entrepreneurship. Under this paradigm, education is driven by basic principles that include:

1. centrality of students in the learning process and the role of teachers as facilitators rather than disseminators of information,
2. encouragement of students to achieve their learning goals while teachers give them support,
3. invitation of students to discuss what content to be covered and the competencies to be developed,
4. no evaluation of students' performance through the use of tests, instead students' learning assessed while they exercise relevant activities that imitate real-world situations,
5. encouragement of students to interact with their peers in group work activities and class discussions while receiving feedback from teachers, and
6. encouragement of students to solve problems on their own while asking motivating questions that lead them to find solutions (pp105).

The study followed the basic principles of constructivism. Students were given the opportunity to achieve learning by accepting different perspectives on issues and solutions to problems, by modifying existing conceptions in the light of new information, and by creating a motivating environment that promotes active participation of students. The study claimed that constructivism provides the theoretical underpinning that supports much of how entrepreneurs learn and what they do in their entrepreneurial endeavors. Through this approach, students were enabled to learn by doing as opposed to just listening, reading, and working through routine exercises. As the researcher found a positive impact on the students' development of entrepreneurial competencies, working on relevant activities made students internalize those competencies as a part of their behavior or thinking. The research advocated that once these competencies are internalized, entrepreneurial self-efficacy beliefs are enhanced which, in turn, positively influence intentions to new venture creation. After discussion, the conclusion was that entrepreneurial competencies can be learned and changed through the course of an intervention supported by the constructivist principles.

Anyanwu (2008), in a recent doctoral research study identified a theme of the research as the implementation and evaluation of a constructivist intervention in secondary school science teaching. The purpose of the study was to investigate the effect of the constructivist teaching model as an intervention to facilitate conceptual change. Basically the study was concentrated on investigating to what extent the constructivist teaching model facilitates conceptual change and to investigate if the paradigm shifts from the traditional method to the constructivist method of science teaching is welcomed. The results of descriptive statistics analyzed showed that the learners who received constructivist instruction preformed better than the learners that received traditional instruction in terms of formulation of ideas, searching for new ideas, reviewing the meaning, and transfer of knowledge. The study resulted that the difference in the means of the two groups on each of the sub variables of conceptual change was significant. The study claimed that constructivist teaching model was dominant over the traditional model. On the ground of the evidence gathered through the observation and measurement, this study concluded that the constructivist approach to science teaching is more effective than traditional lecture approach in facilitating the ability of secondary school learners to reconstruct ideas. This study also found that science educationists welcome the paradigm shift from the traditional approach to the constructivist approach. These contemporary related research studies have confirmed that the constructivist approach to science learning have positive effects from different contexts. The results suggested that constructivist instructional models produce significant gains over traditional instruction in learners' understanding of science concepts and principles. However there is still need of integrated study of constructivist approach, learning design approach and experiential learning style preferences on learning scientific knowledge.

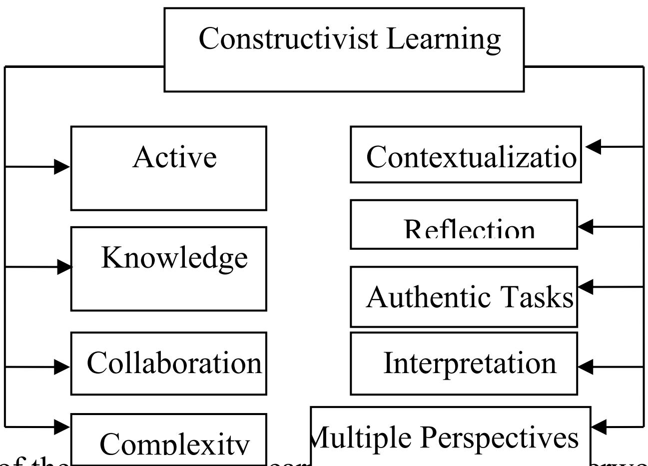
In conclusion, my focus was that there is need of further study about the learning style preference to tie up with the technology to follow the constructivist learning approach in teaching learning activities of science learning. Further research and development should occur in the area of instructional design, calling upon constructivism and cognitive tools theory to bridge the space that exists for students who are introduced to these ideas for the first time in secondary science education. The study should also concentrate on integration of psychological aspect including action and reflection with philosophical aspect including viability and autonomy as well as with anthropological aspect including scaffolding and ethnography. Different studies have also demanded the incorporation of different dimensions of the learning design with respect to technology while applying constructivist learning design strategies in science learning. It is also necessary to incorporate the experiential learning style preferences while learning science. The mastery of designing constructivist learning environment based on experiential learning style preferences is the area for the present study for science learning. This research study has aimed to better understand the nature of administrator reluctance toward new practices, as well as how the increased leadership capacity for teachers engaged in learner-centered professional development impacts the roles and relationships within the traditional educational hierarchy. This would be an integrated study of constructivist approach, learning design approach and experiential learning style preferences on learning scientific knowledge.

Theoretical Construct

An attempt was made to generate a framework for the design of instruction and learning resources. No such design framework, clustering dimensions derived from the theoretical framework of the context of this study, was found in the relevant literature. It was upon this set of design principles that the learning resources and instruction were designed and developed. The congruencies or inter-referencing of the three sets of guidelines (of constructivist principles, learning design principles and learning style principles) was established and a design framework was generated as a guide for the implementation of the learning resources. Constructivism is a very broad conceptual framework in philosophy and science and many theorists represent a variety of perspectives. Constructivist theory is a general framework for instruction based study of cognition. According to Bruner (1996), the learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Learning, teaching, and conducting research involve social interactions but each person must make personal sense of these experiences (Driver, 1995). Constructivist teaching is based on the premise that a person must create his or her own interpretation of knowledge from his or her own mental structures (schema), prior experiences, and social, physical, and mental interactions with the concept to be learned. A world view of constructivist-based teaching provided a theoretical framework for the construction and interpretation of data during the present study. I, with a constructivist world view, designed and conducted this study. The theoretical construct for this research explains how constructivist-based teaching is an active process in which students constructs new concepts/ ideas based upon their current/ past knowledge, how students create meaning during classroom instruction, how they develop student ownership for their own learning, and how they explain or interpret situations and understandings in a secondary level science classroom.

Lackney (2003) emphasized that each educational design principle takes as an underlying premise that all learning environments should be learner-centered, developmentally and age-appropriate, safe, comfortable, accessible, flexible, and equitable. These premises should run through all principles and should be understood to underline the appropriateness of each principle in practice. Constructivism holds that while there is a real world, there is no meaning inherent in it. Meaning is imposed by people and culture. Constructivism predicates the construction of knowledge by learners on their interactions with the natural world in a socio-cultural context, mediated by their prior knowledge (Henning, Mamiane, & Pheme, 2000). In light of the above, the main design principles derived from constructivist perspectives on learning, as revealed by literature, are generated as follows:

Figure 2.11: Constructivist Learning Principles



The components of the constructivist learning principles are interwoven to each other as they produce synergy on joint action. The following are the nine components incorporated in this context:

a. Action and manipulation: The learning process engages learners in mindful processing of information, in which they are responsible for the result. Knowledge is not passively received either through senses or by way of communication, but is actively built up by cognizing subject, manipulating objects and tools of the trade and learning by reflecting on what they have done (Chrenk, 2001).
b. Knowledge construction: Learners integrate new ideas with prior knowledge in order to make sense or make meaning or reconcile a discrepancy, curiosity or puzzlement. They construct their own meaning from different phenomena (SEDL, 1999).
c. Collaboration: Learners naturally work in learning and knowledge-building communities, exploring each others' skills, while providing social support and observing the contributions of each member. Humans naturally seek out others to help them to solve problems and perform tasks (Cottone, 2001).
d. Complexity: Learning situations need to engage learners in solving complex and ill-structured problems as well as simple problems. Unless learners are required to engage in higher order thinking, they will develop oversimplified views of the world (Jones, 1997).
e. Contextualization: Learners access background and contextual materials of various sorts, which aid interpretation and argumentation. When learners are provided with authentic contextual materials, they are able to practice and transfer ideas to other contextual situations (Black & McClintock, 1995).
f. Reflection: When learners articulate what they learn, they reflect on the processes. They understand more, and are entitled to use knowledge that they have constructed in new situation (Boyle, 2000).

g. Authentic tasks: Learners must see the relevance of the knowledge and skills to their lives, and the leverage it provides in problem they see is important. This will allow them to maximum transferability to new challenges, as they appear (Boyle, 2000).

h. Interpretation: Information is shifted by the individual to create beliefs from interpretations of self-referent information and environmental contingencies. The construction of meaning relies on interpretation (Airasian & Walsh, 1997).

i. Multiple perspectives: Learners learn in variety of ways. The more opportunities they have, and the more actively engaged they are, the richer becomes their understanding (Black & McClintock, 1995; Wilson, 1997).

Table 2.3 represents a summary of constructivist principles as derived from constructivist theory revealed by literature review.

Table 2.3

Deriving Principles from Constructivist Theory

SN	Essential Characteristics	Guiding Principles
1	Generation of new ideas with prior Knowledge by learners and construction of their own meaning	Learning material should allow learners to construct knowledge and meaning
2	Active engagement of learners in processing of information and thus knowledge built up by manipulating the learning content actively	Learning process should enable learners to be actively engaged and manipulate the learning content
3	Knowledge is constructed within a social context, learners to explore view point of others and to collaborate in the learning process	Knowledge should be constructed within a social context

4	Engagement of learners in solving complex and ill-structured and also simple problems	Learning content should engage learners in solving complex and ill-structured and simple problems
5	Learners access background and contextual material of varies sorts aid interpretation and argumentation, leading them to transfer ideas to other contextual situation	Contextual material should permit interpretation, argumentation and transference of ideas to different contextual platforms
6	Learners articulate what they learn, reflect on the process in order to understand more and to use constructed knowledge to other situations	During and after the learning process, learners should be able to articulate what they learn and reflect
7	The relevancy of knowledge and skills to their lives and solving authentic problems to new challenges.	Learners have to see the relevancy of knowledge and skills to their lives and they must be able to solve authentic problems to new challenges
8	Construction of meaning relying on interpretation and as such there is no reality without interpretation.	The design of learning environment ought to empower learners to interpret the learning material.
9	Learning in a variety of ways and from different perspectives for a richer understanding.	Learners must be given the opportunity to be engaged and from learn from different perspectives for a richer and better understanding

Generic Design Principles from the Learning Design Theory

The point of departure in discussing the learning design principles is grounded in the notion of learning design as a systematic approach to design instruction and learning materials to achieve specified learning outcomes (Bostock, 2001).

Furthermore, learning design focuses on what learners are to know, the information to be provided (Smith, 2001), and the process through which an educator determines the best teaching methods for specific learners in a specific context. With this in mind, the six learning design principles were derived from learning design component of literature review that is presented as follows:

a. Cognitive learning theory: Cognitive science views learning as a process that supports cognition, formation of internal knowledge structures within the learner, and retention. Cultivating cognitive processes is seen as more important than generating learning products. Critical thinking skills are fostered in learners in the context of authentic problem solving or by explicit teaching of cognitive strategies along with the content knowledge.
b. Constructivism: Constructivism is not direct instruction; rather it entails setting up learner centric environments and activities. The aim is to instill personal goals and secure active involvement in knowledge construction within real world situated learning, resulting in the type of knowledge attainment that results in applicatory skills, and effective transfer. It emphasizes collaborative activities and learner-research using a wide variety of multi-media resources.
c. Components: Component display theory (CDT) (Merrill, 1983) examined whether the instructional strategies used in a learning event can effectively achieve its instructional goals. However, the choice of components as an element of the framework goes beyond CDT, in that it relates to the basic knowledge/ skills of a domain.

d. Collaborative learning: Collaborative learning involves joint work, sharing responsibility within a group. It optimizes complementarities and instills collaborative skills in learners.

e. Customization: Customized learning aims for instruction that adapts individual learners' profiles, supporting personal processes and products, and allowing learners to take initiative with regard to (some or all of) the methods, time, place, and content of their learning. It supports the culture of matching learners' needs and interests within the context of instruction/learning.

f. Creativity: Creativity supports the affective aspects of instruction, aiming for novelty within functionality, in ways that motivate learners intrinsically.

Design principles from the Perspective of Learning Styles

It is acknowledged that several theories and models exist that describe and typify learning styles, but, for the purpose of this research study, the KLSI is selected as a theoretical point of departure. The experiential learning cycle was tied into Kolb's Learning Style Inventory. The learning cycle involves four processes, which are concrete experience; reflective observation; abstract conceptualization; and active experimentation (Raschick et al, 1998). However, learners begin at different points of the cycle and may not progress in a systematic manner. The Kolb's Learning style Inventory categorizes learners as being accommodators, divergers, assimilators and convergers (Dangwal & Mitra, 1999). Learning materials require a variety of elements that accommodate each type of learner.

1. Solution-oriented reality: Accommodators, or activists, require a solution-oriented reality and experience reality concretely at first, but move to process it through active experimentation. They are risk takers and accommodate well in new circumstances using trial and error (Smith, 2001). Accommodators' strength

lies in doing things and involving themselves in new experiences. They are characterized by creative experience and active experimentation (Clark, 2000). Since this is so, accommodators are at ease with people, they like to rely on other people's analysis. Their learning environment should involve practicing skills and solving problems that incorporate group decision and peer group feedback, for leading to success (Bonner II, & Hairston, 2001). Lord (1998) added that when activists are engaged in activity, they enjoy new experiences, intuitive decision-making and enhanced group-work.

2. Perceptual interpretation: Divergers, or reflectors, require opportunities for perceptual interpretation. They view a situation from different perspectives and rely heavily upon brainstorming and generation of alternative ideas (Bonner II, & Hairston, 2001). According to Couger (1995), divergent knowledge is very broad, and focuses on creativity and the description of experiences or searching for a variety of answers to questions. Smith (2001) contends that reflectors are strong in imaginative ability, good at generating ideas and seeing things from different perspectives. Since divergent learners use reflective observation, and create experience, they review what has been done and use the skills they have in attending, noticing differences, and applying terms. These help them to identify delicate events and communicate them clearly to others (Clark, 2000). Honey and Mumford (1992) added that reflectors are cautious and thoughtful people who like to consider all the possible angles before making any decisions, and their actions are based on observation and reflection. Divergers integrate experiences with self, and need to be personally engaged in the learning process (Brown, 1998). Clark (2000) concluded that the teaching approach should

provide plenty of reflection time, expert interpretation and judgment of performance by external criteria in order to accommodate divergers.

3. Reflective interpretation: Assimilators, or theorists, like to learn by using abstract conceptualization and reflective observation on lectures, papers or analogies. They enjoy reflective interpretation and ask such questions as “How does this relate to that?". (Clark, 2000) stated that assimilators grasp experience abstractly at first, than through reflective observation. They like to assimilate diverse facts into theoretical models, focusing upon validation of the ideas or theories themselves. In fact, assimilators' strengths lie in the ability to create theoretical models. They excel in inductive reasoning, concerned with abstract concepts and less concerned with practical applications of knowledge (Clark, 2000). According to Ross et al (1994) instructional material should be designed in a manner that involves learners in interpreting the events that have been noticed and understanding the relationship among them. Clark (2000) added that these learners look for an instructor who is a taskmaster and a guide.
4. Practical experience: Convergers, or pragmatists, enjoy practical experience. They like to learn using abstract conceptualization and active experimentation, and like to ask questions such as “how do I apply this in practice?” (Clark, 2000). A converger is classified as someone who wants to solve problems and who relies heavily upon hypothetical deduction, focusing on specific problems (Bonner II, & Hairston, 2001). According to Honey and Mumford (1992), pragmatists are learners who like to apply new ideas immediately. They get impatient with an emphasis on reflection. The learning environment, therefore, should enable them to take new understanding and translate it into a prediction about what is likely to happen next (Ross et al, 1994). Clark (2000) explained

that pragmatists' greatest strength is in the practical applications of ideas. The learning environment should thus be designed in such a way that these learners are engaged in projects, problem-solving and practical activities. They like to see everything and determine their own criteria for the relevance of the materials. Table 2.4 represents a summary of learning style principles extrapolated from KLSI.

Table 2.4

Deriving Principles from Learning Style According to KLSI

SN	Essential Characteristics	Guiding Principles
1	An individual learner focuses less on people but more concerned with ideas and concepts based on sound theoretical foundation rather than on practical value.	The learner is able to reason inductively, and creates theoretical/conceptual models into an integrated explanation.
2	The learning situation creates many perspectives for the learner to brainstorm and generate alternative ideas.	The learner is able to view concrete situations from different perspectives through observation rather than action.
3	The learner does best in the situations where he/she adapts to the changing immediate circumstances and takes the opportunity to take action.	The learner is actively involve in carrying tasks, plans and also getting involve in concrete new experiences through action.
4	Learners learn best through practical experience, active experimentation and apply new ideas immediately to other location and test them.	The learner should be able to reason and solve practical problems.

Deriving a Set of Integrated Design Principles

An attempt was made to summarize the three dimensions, derived from the theoretical exposition, in the form of integrated design principles for the purpose of the present study. Figure 2.5 illustrates the integrated design principles.

Table 2.5

Integrated Design Principles

Constructivist principles	Learning Design Principles	Kolb's Learning Style
1. Learning process should enable learners to actively engage with and manipulate the learning content.	1. The presentation of a learning platform must be kept consistent throughout the application.	1. The learner is actively involved in carrying out tasks and plans, as well as being involved in concrete new experiences through action.
2. Instructional material must allow learners to construct knowledge and meaning.	2. The presentation of the interface must be relatively simple and easy to follow for effective learning.	2. The learner is able to view concrete situations from different perspectives through observation rather than action.
3. Knowledge is constructed within a social context.	3. The learner must initiate and control action, and must have the sense mastery over the tool.	3. The learner is able to reason inductively, and creates theoretical models into an integrated explanation.
4. Learning content must engage learners in solving complex, ill-structured as well as simple problems.	4. Informative and appropriate feedback must be provided for the progress made.	4. The learner should be able to reason and solve practical problems.
5. Contextual material should permit interpretation, argumentation and transference	5. Due to human short-term memory, learners must be allowed to organize content	

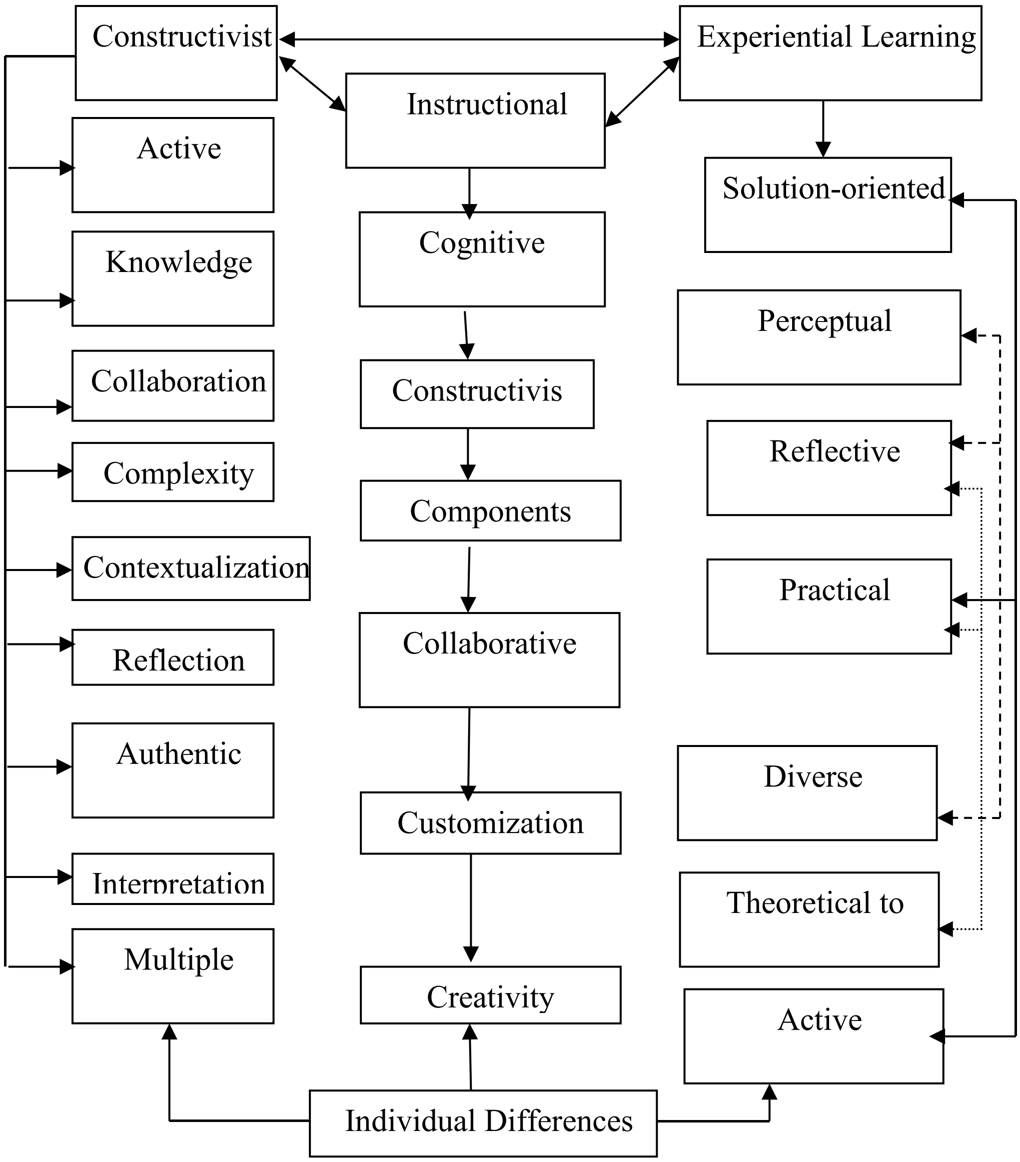
of ideas to different contextual platforms.	than to recall.	
6. During and after the learning process, learners should be able to articulate what they learnt and reflect for better understanding	6. The material provided to the learner must be familiar to them so as to evoke their prior knowledge.	
7. Learners have to see the relevance of knowledge and skills to their lives, and they must be able to solve authentic problems in new situations.	7. Information presented on the class should be logical, followed by expectations of user and task requirements.	
8. The design of the learning environment ought to empower learners to interpret the learning material in any given context.	8. Learners should always get help: either procedural help or information help within the content.	
9. Learners must be given the opportunity to be engaged with the content and to learn from different perspectives for a richer and better understanding.	9. Users of the learning resources must have instant access to the functions they use and features that help to escape or end their current session.	

The above table was used to summarize the design principles, derived from the theoretical exposition, for the design and development of a constructivist instructional/ learning design.

The Congruencies of Constructivism, Learning Design and Learning Styles

The previous paragraphs concisely examined the concepts of constructivism, learning design and learning styles (according to Kolb's Learning Style Inventory). In figure 2.12, an attempt was made to tabularize these dimensions in the form of design principles, derived from the theoretical exposition. These principles provided a framework for the design and development of the learning resources and strategies. The specific concepts derived from the three sets of principles were used to illustrate the congruencies that exist between them.

Figure 2.12: Congruencies among Constructivism, Learning Design and Learning Styles



The congruencies of the two among the constructivist principles, instructional design principles and experienced learning style principles were delimited to the binary relations among them to avoid multiplier effects and emerging themes were attempted to generate from the research findings. The congruencies were further focused on the individual differences in learning.

Chapter Summary

This section was built on the theoretical construct from which the theoretical research framework was derived. A brief description of the theoretical framework was given, organized around the three integrating themes: constructivist learning theory, Learning design and learning styles. The design principles derived from the three sets of constructivist principles, learning design principles and learning style principles (KLSI), were established and discussed. The constructivist epistemology in science education was presented with the incorporation of evidences from the contemporary research findings. An integrated design principles rubric to assess the students' perceptions on the design of the instructional resources and strategies was presented. The learning designs for the students were built in accordance with these criteria. The next chapter presents the research methodology applied in the research in detail.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

This chapter details out the research methodology related to the present study. The researcher's purpose for this study is to explore the secondary level science classroom of a teacher and examine how constructivist-based teaching influences the students and their learning science. The major research question asked in this research study was:

> How can a concise framework of learning be designed and developed that accommodates learning styles principles, constructivist perspectives on learning, and instructional design principles?

To accomplish this purpose, the chapter as a whole explains the nature of the research, research design, including the logical framework, sources of information, data collection methods, instrumentation, techniques of data reduction and analysis, strategies of minimizing errors, validity and reliability of the information.

Nature of the Research

There is hardly any studies conducted examining the constructivist approach of science learning of students in Nepal. This study was thus an exploratory and descriptive research based on qualitative and quantitative research approaches. According to Leedy (1997), researchers do two things in employing descriptive method. They observe with close scrutiny the population bounded by the research parameters, and make a careful record of what they observe so that when the aggregate record is made, the researchers can then return to the record to study the observations described.

Philosophy of the Research Study

Researchers state the paradigmatic assumptions underlying their research so that the reader can establish an overview of their position (Miles & Huberman, 1994). Behr (1983) defines the concept paradigm as an expression of the configuration of beliefs, values, explanations and basis for the solution of a problem, while Kuhn and Martorama (1982) regard it as a cluster of beliefs that influence what should be studied, how research should be conducted and how the results should be interpreted. Each and every research is undertaken within certain assumptions and educational researchers are no exception. Behr (1983) defines the concept paradigm as an expression of the configuration of beliefs, values, explanations and basis for the solution of a problem while Kuhn and Martorama (1982) regard it as a cluster of beliefs that influence what should be studied, how research should be conducted and how the results should be interpreted. According to Gephart (1999) three paradigms are prominent in contemporary social research – positivism, interpretivism and critical postmodernism:

A Positivist Framework. it infers an objective world rejecting metaphysical nature of science (Gephart, 1999). It is concerned with uncovering truth and presenting it by empirical means (Henning, Van Rensburg & Smit, 2004). This position assumes that knowledge stems from experience and observation. It is challenged by interpretivists who assert that these methods impose a view of the world on participants in research rather than capturing, describing and understanding their world views (Gephart, 1999).

An Interpretive Framework. it is underpinned by observation and interpretation, thus to observe is to collect information about events, while to interpret is to make meaning of that information by drawing inferences or by judging the match between the information and some abstract pattern (Aikenhead, 1997). In this regard, Henning et al. (2004) remark that within the interpretive paradigm, knowledge is constructed not only by observable phenomena but also by descriptions of people's intentions, beliefs, values and reasons, meaning making and self-understanding.

A Critical Post-modernistic Framework. the critical theory seeks to deconstruct the hidden curriculum or text and search for the truth and understanding within the social context (Reeves & Hedberg, 2003). The paradigm of critical theory encourages evaluators and instructional designers to question and also to evaluate the cultural, political and gender assumptions underlying the effectiveness of the instructional product or programme (Reeves & Hedberg, 2003).

Following the above philosophical assumptions, the following are the justifications of the researcher to position in the context of the above perspectives. Firstly, identification of learning style preference offers the instructional designer good opportunity for allocating learning resources (Kolb, 1984). In light of this, the researcher position himself within the positivistic discourse, for learning resource preference, virtual classroom, multimedia support, self learning materials and project based learning. They can create environments that can be verified through experience and observation. In addition, the researcher holds the interpretive view that learners, as individuals, construct their own knowledge and meaning within the socio-cultural context influenced by their prior knowledge and understanding. Consequently, the learning environment could be created in such a manner that learners could express their understanding in the learning process. This view is shared by the critical paradigm (Henning et al., 2004). As a critical researcher, the researcher endorse the belief that when learning materials are evaluated in terms of learners' preferences, concrete experience and knowledge, this could emancipate and liberate them in becoming critical reflectors and the designers of their own worlds rather than becoming passive recipients of information. In addition to the above perspectives, the researcher position as a researcher within the parameters of a constructivist epistemological discourse. The interpretivist framework described earlier and the use of constructivist framework of instructional systems design as a theoretical lens is best suited to a qualitative strategy. A qualitative strategy is based on a constructivist philosophy that assumes reality as a multiple layered, interactive social construction.

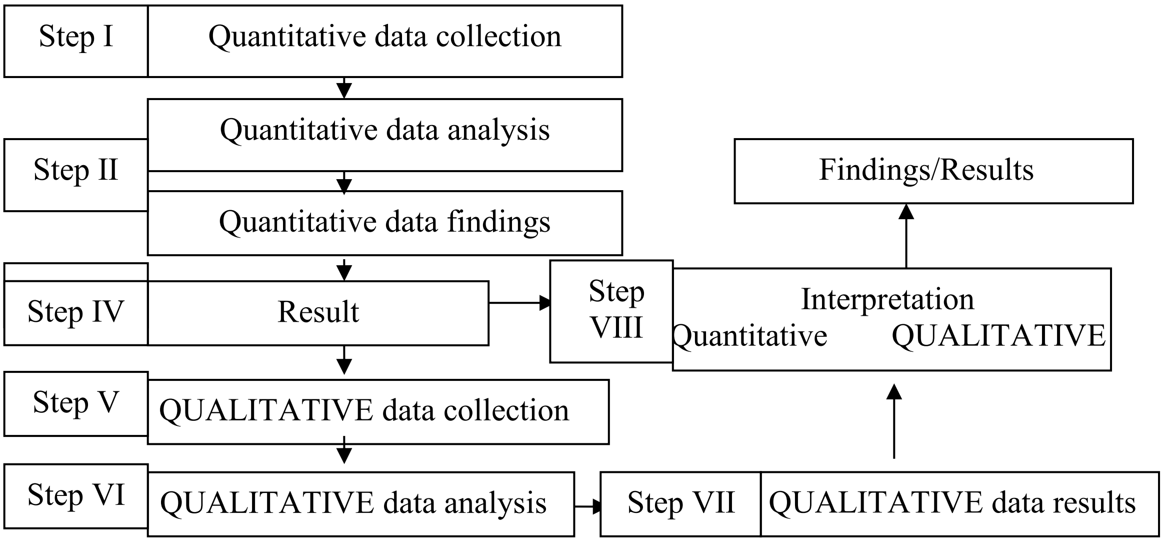
The purpose of this study is to explore the epistemological and ontological knowledge with the process of transforming things believed into things known. The next section describes the research design of the study.

Research Design

A research design provides the glue that holds the research project together (Trochim, 2002). It is used to structure the research, to show how all of the major parts of the research project -- the samples or groups, measures, treatments or programs, and methods of assignment -- work together to try to address the central research question and purpose.

The purpose of this study was to explore the secondary level school science classroom of constructivist-based teachers and examine how constructivist-based teaching influences the students and their learning of science. This study was based on the mixed method research design selected to increase the understanding of the emergent model, giving special attention to the influence of the rapidly developing field of information technology, within the classroom learning environment. The research design was grounded in the naturalistic paradigm and methods employed were integrated into the overall design in an overt manner to model the evaluation and assessment of teaching and learning. Out of nine mixed methods design in practice (the inclusion of a quantitative phase and a qualitative phase in an overall research study), the researcher made the primary decision to operate largely within qualitative dominant paradigm (Morse, 2005). Figure 3.1 illustrates the schematic representation of the research design applied in the study.

Figure 3.1: Schematic Representation of Mixed Method Research Design



In this research study, the researcher collected the quantitative data first, analyzed the quantitative data and extracted results through interpretative approach. On the other hand, the quantitative data concerning the learning style preferences and other related information were collected and analyzed using statistical tools. The information generated through quantitative data was studied qualitatively to generate findings regarding constructivist approach of learning in classrooms of Nepal.

Theoretical Perspectives on Mixed Methods

Mixed methods research is formally the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study. This method as the third paradigm can also help bridge the schism between quantitative and qualitative research (Onwuegbuzie & Leech, 2004). Research in a content domain that is dominated by one method often can be better informed by the use of multiple methods. A key feature of mixed methods research is its methodological pluralism.

The majority of mixed methods research designs can be developed from the two major types of mixed methods research: mixed –model (mixing quantitative and qualitative approaches within or across the stages of the research process) and mixed method (the inclusion of a quantitative phase and a qualitative phase in an overall research study). Nine mixed method designs(Morse, 2005) are in practice in which the researcher must make two primary decisions whether one wants to operate largely within one dominant paradigm or not and whether one wants to conduct the phases concurrently or sequentially.

The mixed methods research has strengths in the field of educational research. Words, pictures, and narrative can be used to add meaning to numbers in mixed methods. Numbers can be used to add precision to words, pictures, and narrative. The mixed methods can provide quantitative and qualitative research strengths and the researcher can generate and test a grounded theory. Similarly, these methods can answer a broader and more complete range of research questions because the researcher is not confined to a single method or approach. The specific mixed research designs have specific strengths and weaknesses that should be considered (e.g. in a two-stage sequential design, the Stage one results can be used to develop and inform the purpose and design of the Stage two component). A researcher can use the strengths of an additional method to overcome the weaknesses in another method by using both in a research study. These methods can provide stronger evidence for a conclusion through convergence of findings and can add insights and understanding that might be missed when only a single method is used. The method can be used to increase the generalizability of the results. Quantitative and qualitative research used together produce more complete knowledge necessary to inform theory and practice (Creswell, 2003).

The mixed methods research process comprises eight distinct steps: determination of the research questions, determining whether mixed design is appropriate, selection of the mixed method or mixed model research design, collection of data, analysis of data and drawing conclusion. The benefits of moving beyond the traditional practice of choosing either quantitative or qualitative research methodologies have been suggested by Fraser (1988). He has successfully combined qualitative and quantitative research methods in studying the classroom learning environment at different grain sizes to show how individual students and the teacher could be investigated at the class level, school level, or system level. Using mixed methods in research and evaluation offers methodological and practical advantages. Methodologically, mixed methods research and evaluation combine quantitative and qualitative methods, approaches, and concepts that have complementary strengths and non-overlapping weaknesses (Johnson and Turner, 2003).

In 1989, Greene, Carcelli, and Graham outlined five rationales for conducting mixed methods research: triangulation, complementarity, initiation (discovering paradoxes and contradictions that lead to a reframing of the research question), development (using the findings from one method to help inform the other method), and expansion (seeking to expand the breadth and range of research by using different methods for different inquiry components). When considering educational research, both qualitative and quantitative data have great relevance for the improvement of education and in fact can be supportive to each other on understanding the main factors that impact on education (Wiersma, 1991). A brief discussion of the basic principles of quantitative and qualitative research approaches applied in this research study is discussed in the following sections.

The Quantitative Research Approach

In this research study, the questionnaire relating to experiential learning style preference was used to determine the learning style preference of school students prior to the implementation of the constructivist learning strategies, open learning environments; problem based learning approaches and collaborative project templates. Kolb's Learning Style Inventory (KLSI) (Kolb, 1984) was also used in this study as a quantitative research tool to determine the learning styles (accommodator, diverger, assimilator and converger). The purpose of KLSI is to establish participants' learning style preference and accommodate them in the design and development of the learning materials. Besides these, the results of the achievement tests were also analyzed quantitatively.

Population and Sampling Procedure

Processing of descriptive, quantitative data involves careful assimilation and analysis of responses in terms of numbers, and manual classification of data. The small group size of sample from the population would be manageable for the researcher.

The population of the area segregated covered the hills, valleys and Terai regions including the districts Jhapa, Sindhuli, Nuwakot, Kathmandu, Lalitpur and Bhaktapur. The population covers the schools with higher percentage in SLC results, with all the categories of schools existed, and availability of learning resources. The achievements and the number of schools as well as number of students of the selected areas correspond to be higher in comparison to other areas. Out of total 6930 schools, 3158 are government funded, 1844 are trust and 1928 are institutional in Nepal based on Flash Report 2007/8. The districts selected for the study covers the population of schools as:

Table 3.1
The Population Distribution of the Study Area

School Category / Districts	GS	TS	IS	Total
Jhapa	82	28	110	220
Sindhuli	42	39	15	96
Nuwakot	41	50	4	95
Kathmandu	132	32	499	663
Bhaktapur	34	10	117	161
Lalitpur	89	13	163	265
Total	420	172	908	1500

GS: Government Funded, TS: Trust School, IS: Institutional School, Source: Flash Report 2007/8, DOE.

In order to select the students and teachers, the researcher used a criterion-based selection process, which is a common form of cluster sampling. In this type of sampling the investigator wanted to understand the problem and benefits by selecting a sample from which the most can be learned. In criterion-based sampling the researcher selected attributes desired for the study and found subjects that matched.

The survey was conducted in 2008/9 from different parts of the country focusing the areas: Jhapa, Nuwakot, Sindhuli, Pokhara, Bhaktapur, Lalitpur and Kathmandu. They all were the initial pool of teachers to select from because they were exposed to constructivist learning science in secondary level school students through the three days workshops. The contents of the workshops were the theoretical aspects of constructivism, the constructivist strategies of learning and assessment. All the teachers were considered based on their teaching methods and their years of teaching. All teachers were evaluated on their level of constructivist teaching based on the teachers' responses to a survey given to them at the end of the workshops. Science lessons were observed throughout the workshops and the participants were given survey forms to describe their teaching. Each participant in the workshop was observed using the Expert Science Teaching Educational Evaluation Model (ESTEEM). Three teachers were identified who provided the strongest examples of constructivist-based teaching in each category of community based secondary schools, trust schools and institutional schools. From the 182 science teachers, three teachers were selected based on their classrooms and school demography as the sample classes were preferred having more diverse ethnic composition.

Table 3.2

The Population and Sample of the Research Study

School Category	Number of Schools	
	Population (N)	Sample (n)
Community	420	62
Trust	172	35
Institutional	908	85
Total	1500	182

The sample of the population for using strategies: TBIPE, PBLE, OLE, and CLE were of randomly selected students of each category schools. The number of students in a class legally valid to study in secondary level is up to 40 in Nepalese school (Education Act, 2000). The participants were selected based on the judgment and purpose of the researcher as Kruger (1988) stated, those that have had experiences relating to the phenomenon to be researched.

The detailed study location was Kathmandu valley as the secondary level teachers of schools found in Kathmandu valley alone was 6582 out of total teachers 26,925 based on flash report 2007/08. There are 19202 trained teachers out of 26925 secondary level teachers of the country. Among them 13,474 are trained teachers from government funded schools. Student teacher ratio in Kathmandu valley is least which is 11.3 only. Lower secondary level to secondary level student transition in Kathmandu valley is 93.1 which is high and within which Kathmandu and Bhaktapur has 97.6 the highest among other districts. The dropout rate in secondary level in Kathmandu valley is least which is 1.2% as compared to national level 2.8%. These figures helped the researcher to make the sample more justifiable for the quantitative research study.

Table 3.3

The School Category and Participants

School Category	Participants		
	No. of Student	No. of Teacher	No. Headteacher
Community	56	5	1
Trust	82	5	1
Institutional	36	5	1
Total	174	15	3

Each of the category of schools from community, trust and institutional is made the premise for the study. Chapter IV shows the detail setting of the research milieu. All the students of grade nine, science teachers teaching the subject matter and the head teachers from the respective schools as mentioned in table 3.3 were taken as participants in the study.

Quantitative Data Collection

Data Collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. The data were analyzed to identify how constructivist-based teaching was being used in the secondary level school science classroom, and how this teaching helps them understand science.

The tools used for the quantitative data collection included the questionnaires, learning style inventory, and assessment tools. The questionnaires used were closed ended and about basic information. The learning style inventory was based on David Kolb's learning style inventory. The following section deals with the quantitative data collection tools used.

ESTEEM Instruments

The ESTEEM (Burry-Stock, 1995) was developed by Judith Burry-Stock at the University of Alabama to enhance professional development in science teaching. It was developed through a US Office of Educational Research and Improvement (OERI) project supported by the Center for Research on Educational Accountability and Teacher Evaluation (CREATE) that was directed by Dan Stufflebeam (Burry-Stock, 1995). It was developed according to a combination of constructivist and expert teaching philosophy. The emphasis of the ESTEEM model is student-centered teaching that promotes meaningful, conceptual learning. The model can be implemented by a teacher, or an external person, or can be self-administered (Burry-Stock, 1995).

Currently there are five ESTEEM instruments that are designed to assess expert science teaching from multiple aspects of teaching practices and student outcomes; all of these instruments have been field tested. These instruments are used as diagnostic tools and templates of best practice. Two of the ESTEEM instruments are inventories that use Likert-type formats, and three instruments are rubrics.

The two ESTEEM inventories are the Teaching Practices Assessment Inventory and the Assessment of Classroom Learning in Science Inventory. These inventories were used to assess the science teacher's teaching behaviors. The three ESTEEM rubrics are the Science Classroom Observation Rubric, Student Questions and Student Outcome Assessment Rubric, and the Concept Mapping Rubric. The Science Classroom Observation Rubric was used to assess the teaching behaviors. The Student Questions and Student Outcome Assessment Rubric, student constructed concepts maps and the ESTEEM Concept Mapping Rubric was used to assess students' understanding of the concepts being taught.

The categories of teaching behaviors assessed by the rubric are: Facilitating the Learning Process from a Constructivist Perspective, Content-Specific Pedagogy Related to Student Understanding, Context-Specific pedagogy Related to Teaching, and Content-Knowledge. The rubric has a scale from "0" (no behavior is exhibited) to "5" (the behavior is exhibited at the "expert" level). The mean of the totals is computed and the overall total is converted into a percentage for each science lesson.

The Teaching Practices Assessment Inventory was also used to assess the independent variable cluster of constructivist teaching practices. There are four categories for the Teaching Practices Assessment Inventory. Category 1 Facilitating the Learning Experience, Category 2 Context-Specific Pedagogy Related to Students' Understanding, Category 3 Content Experiences, and Category 4 Content Specific Pedagogy Related to Teaching. The developmental stages designed to assess the constructivist teaching are novice, advanced beginner, competent, proficient, and expert. The percentages for each competency levels are as follows: 85% -100% Expert; 70% - 84% Proficient; 35% - 69% Competent; 15% - 34% Advance Beginner; and 01% - 14% Novice.

The Assessment of Classroom Learning in Science Inventory was used to assess the independent variable cluster of constructivist teaching practices.

There are seven categories for the Assessment of Classroom Learning in Science Inventory. Category 1 Assessment Communication/Enhancing Learning, Category 2 Product Evaluation/Enhancing Motivation, Category 3 Formal Questioning, Category 4 Interacting Feedback, Category 5 Conceptualization Activities, Category 6 Grading Implementation, and Category 7 Immediate Informal Feedback. The developmental stages for the inventory are novice, advanced beginner, competent, proficient, and expert for the inventory. The percentages for each competency levels are as follows: 85% -100% Expert; 70% - 84% Proficient; 35% - 69% Competent; 15% - 34% Advance Beginner; and 01% - 14% Novice.

Questionnaires

Questionnaires were another technique for data collection in this study. Before the implementation of the learning materials, students completed the questionnaires about basic learning skills. The purpose of these questionnaires was to ensure that their use of the self learning materials developed would not be impeded by a lack of basic skills. Data from the basic skills questionnaires were collected and analyzed quantitatively.

Learning Style Inventory

Kolb’s learning style inventory was first published in 1976. It has been used extensively in both academic and professional settings to identify the learning style preferences of different groupings. The Kolb’s updated version of learning style inventory (1985) has been found to be an instrument of high reliability and validity (Healey & Jenkins, 2000). Based on experiential learning theory, the learning style inventory graphs learning along two intersecting continuum:

1. How information is perceived: concrete experience (feeling) to abstract conceptualization (thinking), and
2. How information is processed: active experimentation (doing) to reflective observation (watching) (Barger, 2002).

For these dimensions, Kolb devised and normed four styles of learning: accommodator, diverger, assimilator and converger. The Kolb's learning style inventory score indicates how much the individual relies on the four different learning modes (Bev's Science, 1999). In this study, Kolb's Learning Style Inventory (KLSI) was used to determine to what extent the learning styles of the students were accommodated in the designed learning materials. Data from KLSI were collected and analyzed quantitatively.

Quantitative Data Reduction and Analysis

In case of quantitative data, the researcher personally coded the various measurement scales in the SPSS package and transcribed quantitative data to process out the various statistical results and also to produce various measures of significances. The demographic information was analyzed using simple tabulation. For the purpose of discussions of the qualitative information, necessary qualitative triangulation will be used. Following are some of the considerations made in the analysis of data.

The data collected from basic learning skills questionnaires were tabulated in numbers. This allowed the data to be analyzed statistically (Hittleman & Simon, 1997) and represented graphically for interpretation. Secondly, the data collected from KLSI also were tabulated and presented graphically to describe, compare and to attribute causality.

Framework for the Quantitative Data Analysis

The framework includes principles for the design, based on constructivist learning perspective, learning design strategies and learning styles. The framework for the analysis and classification of the data was developed after an extensive literature review on constructivist learning perspectives, instructional design and learning styles according to Kolb's Learning Style Inventory (KLSI) with basic criteria. Table 3.4 refers to the framework for the quantitative data analysis.

Table 3.4

The framework for the quantitative data analysis

Questions (Themes)	Criteria
Constructivist learning perspective	ESTEEM
Learning style preferences	KLSI

Note: ESTEEM: Expert Science Teaching Educational Evaluation Model, KLSI: Kolb's Learning Style Inventory.

The Validity of Quantitative Data

The reason for combining the quantitative and qualitative approaches using multiple data collection strategies was to improve the validity of the study. This is in fact a form of triangulation that enhances the validity of one's study (Merriam, 1988).

The validity of this research was enhanced by the extensive and participatory nature of the investigations. Reigeluth and Frick (1999) emphasized the importance of construct validity, thoroughness, accuracy (internal validity), and external validity (the extent, to which results could be generalized).

It is assumed that learners in the same stream have similar academic background. To further guarantee validity, the same instruments, persons and procedure were used for data collection in all groups. This measure was taken to ensure that the model produces the effect for which it was designed. The pre-test and piloting of the instrument provided the opportunity to check and revise of the instruments. Training sessions, briefings and debriefings were organized for the science teachers and research assistants who participated in the implementation and evaluation of the constructivist teaching model.

Internal Validity

Internal validity refers to the extent to which the research findings are due to the mechanisms suggested (Cardwell, Clark and Meldrum, 2004).

For this study internal validity refers to the extent to which the findings of the research are due to the advantage constructivist instruction has over traditional instruction. It is assumed that learners in the same stream have similar academic background. To further guarantee validity, the same instruments, persons and procedure were used for data collection in all groups. The design of this study also enabled for the identification and isolation of intervening variables such as class, academic ability, and prior experience, whose presence would have altered the effect if unchecked. This was achieved by ensuring that classes selected were as homogenous as possible. Prior to evaluation, the constructivist teaching model was subject to pre-test. This measure was taken to ensure that the model produces the effect for which it was designed.

Another measure to enhance the validity of the study was adopting the mixed methods approach which integrates the qualitative and quantitative methods. This integration enabled to investigate the effect of constructivist teaching model using different categories of participants as well as multiple tools and strategies for data collection. Training sessions, briefings and debriefings were organized for the science teachers and independent persons who participated in the implementation and evaluation of the constructivist teaching model. These measures were taken to ensure that the effect of the constructivist teaching model was not overshadowed by factor errors.

External Validity

External validity refers to the extent to which the results or a research can be generalized to other settings beyond that were the study was conducted. The external validity of this study was determined from two perspectives: population validity and ecological validity.

From the selected three schools of different background all the students studying science in secondary level grade nine were considered as participants. The science teachers of the respective schools were also taken for the study. It can be inferred that this study has population validity as such its findings can be generalized to the other schools having similar conditions and circumstances.

Ecological validity is a measure of the extent to which the findings of a research can be interpreted to be true in settings different from the one in which it was conducted. This empirical study was conducted under normal classroom conditions. All lessons were conducted during normal class time as the school had scheduled. All learners in the sample schools used in evaluating the effect of the meta-cognitive instructional model were exposed to the same ecological conditions irrespective of whether they were in the experimental or control groups. It is expected that other schools have similar ecological conditions as the sample schools. Therefore the findings can be generalized to all the schools as they have similar settings and conditions as those that were selected and used for this research.

The Reliability of the Findings

The reliability of the study was ensured through the use of multiple source of evidence, which leads to triangulation of data, the detailed, rich and thick descriptions of the researcher's own assumptions and position in the study, data collection, category derivation, decision making procedures and ultimate conclusions. These may lead the accuracy and credibility of the data. For the reliability and validity, designed instruments were tested and feed- backs were collected from experts providing proposal of research. The researcher reworked to modify the tools for further modification of research design.

The Qualitative Research Approach

Qualitative approaches are becoming more wide and used as analysis methods through which people search for better ways of gathering data about a problem (Price, 2002). Maxwell (1998) enumerates five research purposes for which qualitative studies are particularly useful:

1. Understanding the meaning that participants in a study give to the events, situations and actions that they are involved with, and of the accounts they give of their lives and experiences,
2. Understanding the particular context within which the participants act, and the influence this context has no their actions,
3. Identifying unanticipated phenomena and influences, and gathering new grounded theories about them,
4. Understanding the process by which events and actions take place, and
5. Developing causal explanations.

It consists of written descriptions of people, events, opinions, attitudes and environments, or combinations of these. Data is derived from direct observation of behaviors, from interviews, from written opinions, or from public documents

(Sprinthall et al., 1991).

The goal of qualitative research is to understand people, places, or situations. Qualitative research seeks to deeply describe people, their behaviors, experiences, interpretations, and their environment (Creswell, 1998). The focus of studies is a total or complete picture of a situation, person, event, technique, or in-depth view of the environment. The data are the in-depth information regarding situations, experiences, and perceptions of people in their environment. The conditions include the naturalistic investigations conducted; these conditions represent one unique environment. The results include the analysis of data or the patterns, trends, and themes found through the data analysis. Qualitative research emphasizes the importance of looking at variables in the natural setting in which they were found. The interactions between variables are important. The variables explored in the study were the independent variable cluster of constructivist teaching compared to the dependent variable cluster of the science students understanding of science.

There are ten characteristics of qualitative research that were applied to this study: reality, viewpoint, values, focus, orientation, data, conditions, and results (Key, 1997). The existing scenarios of the learning environment, view points of teachers, students and headteachers were considered in the study. The research had concentrated on socio-cultural values, and focused on learning strategies and instructional design. The results were drawn on the basis of data generated and the conclusions were drawn based on the results of the study. Based on the qualitative approach, the researcher explored the constructivist-based teaching of three secondary school science teachers and how their teaching influenced the students and their learning of science.

Qualitative Techniques

Qualitative methods focus on understanding processes, behaviors and conditions as perceived by the individuals or groups studied and can also be used to assess impact. They often yield critical insights into beneficiaries' perspectives, the processes and context that may have affected outcomes and a more announced interpretation of results than is observed in quantitative analysis. The advantages of qualitative methodologies are that they:

1. can be tailored to the needs of the evaluation;
2. allow in-depth study of selected issues, or events;
3. can be carried out quickly by using rapid techniques; and
4. provide critical insights into beneficiary perspectives.

Qualitative techniques are commonly used with quantitative methodologies. While they differ in approach, the strengths and weaknesses of qualitative and quantitative approaches potentially complement each other.

Strategy of the Inquiry

Qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to subject matter, and uses an inductive approach that starts with specific observations of phenomenon that allow categories of analysis to emerge from the study as it progresses. These emerging categories describe routine and problematic moments and meanings in individuals' lives (Denzin &Lincoln, 2000).

The strategy of inquiry for this study was based on case study. The case study evaluations combine qualitative and quantitative research approaches i.e. mixed method approach. Basically, the present study was a qualitative research but it included a significant amount of quantitative observations to establish the further confirmation of the study findings.

The study has an international flavor and it holds relevance to the Nepalese context. The literature resources consulted relate particularly to current learning theories and approaches to the design of instruction focusing on constructivist perspective as well as contemporary instructional practices. The stress was given on the sources that described philosophies, theories, and practices to draw a framework of constructivist learning design. To make the study more scientific as well as systematic, the study was designed in three facets which were:

a. Exploration of learning and instructional theories so as to generate a framework to support development of learning events based on constructivism,
b. Case studies evaluating three learning events viz. technology based interactive practice environment (TBIPE), open learning environment (OLE), problem based learning (PBL) and a project based learning environment (PBLE), using constructivist frameworks as a tool to investigate effectiveness of applied learning products/events, and
c. Determination of further information relating theory to instruction and learning in practice.

As part of exploratory study design, a number of preliminary observations and document analysis were used to explore and to synthesize the findings of the study. These activities supported me significantly to narrow down the statement of the problem for the study and development of the research questions and assumptions. As an alternative, this study is built around the learner centered perspective that the constructivist learning environment is the natural part of the learning and change process.

Capturing data in the workplace requires a principled and ethical approach. This is in order to provide useful and substantiated information on the influence of personal teaching and learning philosophies on the Instructional Designs' design decisions.

The goal of this type of research is to comprehend the particular group/culture through observer immersion into the culture or group. Research is completed through various methods, which are similar to those of case studies, but since the researcher is immersed within the group for an extended period of time more detailed information is usually collected during the research. The qualitative methods in the research provided an in-depth description of programs, practices and settings. The researcher was allowed to interact with teachers and students in the study in a natural and unobtrusive manner. Furthermore, this method allowed the researcher to be flexible by enabling him to develop concepts, insights and understanding from patterns in the data. The researcher was interested to explore how a concise framework of constructivist learning can be designed so as to adapt the learning style preferences while designing learning events and strategies.

In order to understand a phenomenon, reveal the meaning of the situation, or explain a process (how things happen), a descriptive case study is most appropriate because the researcher generally interprets phenomena with details that provide in depth insights into participants' experiences (Cresswell, 1998). An exploratory and descriptive study design was used to examine the relationships between constructivist-based teaching and the students' understanding of science concepts being taught. This study took the form of case study that documented an intervention in a secondary level science course. In this intervention, the researcher attempted to create a constructivist learning environment based on the underlined nine dimensions: active manipulation, knowledge construction, collaboration, complexity, contextualization, reflection, authentic tasks, interpretation, and multiple perspectives. A number of preliminary sample observations and document analysis were used to explore and to synthesize the findings of the study. These activities supported the researcher significantly to narrow down the statement of the problem for the study and development of the research questions and assumptions. The detailed descriptions of the studies played on the strengths of using a narrative approach incorporating five basic human attributes: curiosity, problem solving, imagination, creativity, and the narrative form.

Unlike experimental, survey or historical research, case study does not claim any particular methods for data collection or analysis. Any and all methods for gathering data from testing to interviewing can be used in the study (Merriam, 1988). For this research study, Observations of teaching and learning (including teaching plans and other teaching materials); Interviews related to teaching and learning; Inventories of teaching and learning; and assessments of learning were the key forms of data collection tools.

Participants and Research Milieu

According to Creswell (1998), analysis also includes making a detailed description of the events and the setting. The researcher conducted this study in secondary level science classes mainly focusing in Kathmandu valley. The location covers the largest number of students learning science in English medium. The schools were recognized as the centers for academic excellence as compared to other schools in the area. The computer technology and access were available in the study areas. Most of the schools had limited secondary level classes to 40 students, thus enabling them to sit at tables where they can engage in class discussion, working in groups. Gender balance and participation of students from different socio-cultural background were found in the schools. Annex XI shows the detail setting of the research milieu.

Although constructivism is well suited to learning and does not require that the student be dependable or stable, having subjects that attended class regularly, are willing to participate, and confident in their ability to work with these constructivist methods, is beneficial. The researcher believed these factors as they were influenced by the subjects' background and environment. The researcher allowed the students to form their own groups so that they could take ownership of the works early on, and was motivated to learn with classmates of their choosing.

Nature of Participants

The participants were selected based on the judgment and purpose of the researcher as Kruger (1988) stated, those that have had experiences relating to the phenomenon to be researched. The data collection methods, target groups, the selection criteria and reason, contexts within which the data collection were taken place, and the purpose of each data set in this study are presented in Table 3.5.

Table 3.5

Selection of Participants

Methods	Target groups	Reasons for selection	Selection criteria
Focus Group Discussion	Learners	The learners are at the centre of CLE. Triangulation	They must be Secondary level school learners in science and willing to participate.
Key Informant interview	Instructional Designers, Authors, Curriculum experts, Teachers/ headteacher	Triangulation with the teachers and learners.	They should be aware about science curriculum contents of secondary level science

Observation	Researcher	Triangulation with the teachers and learners.	The researcher should be observer and have knowledge of science curriculum contents

Qualitative Data Collection and Instrumentation

The tools used for the qualitative data collection included the observation, focus group discussion and key informant interviews. The open ended questions used were to explore the perceptions of teachers, headteachers and students. The following section briefly introduces each of the instruments that were used in the data collection process from the perspectives of collecting qualitative data.

Observation

Observational techniques are methods by which individuals gather first hand data on the programs, processing or behaviors being studied. In observation, the researcher became a participant in the culture or context being observed (Torchim, 2002).

In this study, the role of the researcher was that of an observer, that is, during the implementation of the self-learning materials by the students, the researcher demonstrated how the material works and answered the students' queries. Field notes were taken as supportive sources of data collection during the observation. This provided the researcher with: physical trace evidence, recordings of the social situation of the group, and sound (e.g., musical sounds, a child's laughter, and noises) (Creswell, 1998). The researcher recorded each unit looking for, "What is the teacher doing to help the students understand the science concepts being taught?" Each observation took 40 to 45 minutes to complete. Field notes were taken during each observation to determine how each lesson was taught, student reactions to the lesson, student teacher interactions, as well as other evidence of teaching and learning.

The researcher was given the opportunity to examine the teacher's plan book. The researcher observed the teacher using a note book as his planning guide each day. The researcher observed that he planned long term units and lessons. Units and lessons were written at the top of each page with questions following the title.

Key Informant Interviews

When considering the paradigmatic perspective of this inquiry, a constructivist approach to interviewing was a more appropriate method to use. According to this approach, the research participants are regarded as social actors interacting with the interviewer in a communicative event (Henning, 2004). The primary aim of individual key informant interviews in this study was to elaborate on the focus group discussion in order to gain a more profound insight into how the technology based learning materials accommodate the learning styles of the students, the opinion of the participants of the content presentation, the outcomes, the design of the learning materials and the assessment techniques; and their own reflection of the tool as a learning. The key informant interview was conducted with an in-depth, knowledgeable, informed subject who assisted the researcher to gain a deeper understanding of particular issues that were of interest. Students were interviewed at least twice depending on their availability, class, or lesson being taught.

All students interviewed were briefed about what was taking place, who the researcher was, where the researcher was a doctoral candidate, and the purpose for the interview. Students were given the opportunity to ask open ended questions before and after the interviewing process. Students were asked what they were doing, how they were developing their project, and if they understood what their teacher wanted them to do.

The teachers were formally interviewed three times. They were interviewed once at the beginning of the study and before and after the completion of lessons. The interview with headteacher, the other ninth grade science teacher took place in the classrooms. The length of each interview varied between each student and the interview averaged 20 minutes. Each interview with the student lasted for 30 minutes up to an hour.

Focus Group Discussion

A focus group discussion allows the researcher to gain insight into how people construct their world, and the dynamics of group discussion allow an interaction between participants, which leads to added insight and information (Maykut & Morehouse, 1994). Interaction is a unique characteristic of a focus group and therefore the researcher used the focus group discussion as a qualitative technique in the collection of data.

A number of open ended questions were asked with the aim of gaining an understanding of how the students learn best which learning styles they prefer, how they retain information, how they approach the learning tasks; what motivates them to learn; what strategies they use to learn best; and their experiences with technology based education.

Framework for the Qualitative Data Analysis

Keeves and Sowden (1997) argue that theoretical framework serves to focus and restrict the collection of data as well as to guide the reduction and analysis of the evidence collected. Figure 3.2 illustrates how the framework for the analysis was developed.

Figure 3.2: Framework for Data Analysis

Theoretical Data

1. Constructivist Learning Perspectives
2. Instructional Design
3. Learning Style Essentials

↓

Framework for Analysis

1. Constructivist Class room
2. ADDIE model of Learning Design
3. Four Facets of Learning Styles

The aim of developing a framework for the data analysis was to answer the major research question of this study: What framework of learning design would be relevant in the classroom instructional systems of Nepal?

Techniques of Qualitative Data Reduction and Analysis

Data Analysis is the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense and recap, and evaluate data. According to Shamoo and Resnik (2003), various analytic procedures provide a way of drawing inductive inferences from data and distinguishing the signal (the phenomenon of interest) from the noise (statistical fluctuations) present in the data (Shamoo and Resnik, 2003).The aim of analysis and interpretation of qualitative data is to discover patterns, ideas, explanations and understandings (McMillan, 1992) and Cresswell (1994) argues that it is important to note that the process of data analysis is eclectic; in other words, there is no right way of analyzing data. The constructivist approach also aligns with the individualization of learning and complexity of knowledge construction.

Data reduction and analysis in this inquiry were done through the data analysis framework. Open coding, an inductive process, was used to identify the units of meaning. Following the method of coding and content analysis, all the textual data from the transcribed interviews were analyzed by first breaking down the data into segments of meaning and then categorizing the segments.

The researcher analyzed and interpreted all of the data collected, which consisted of observational evidence, interviews, inventory responses, and achievements of learning. The researcher's field-notes were used to record and store data and were a valuable part of the analysis of the study.

In the next step, the researcher looked for trends and patterns in each type of data collected. Teaching plans and other teaching materials were combined with other observational data. Observational data, interviews, inventories, and achievements of learning were each analyzed separately and then compared. Teacher and student behaviors also were analyzed separately and in comparison to one another. The researcher looked for evidence of constructivist teaching and student understanding. The Student Question Response Sheets and Concept Maps were scored by the researcher and member checked by the science teacher.

The researcher used the Expert Science Teaching Educational Evaluation Model categories as an organizational structure for coding. The observational rubric categories of: facilitating the learning process, content specific pedagogy related to student understanding, context-specific pedagogy related to teaching, and content-knowledge were used to categorize or code all observational data. The observational rubric sub-headings from the rubric categories also were used to categorize or code all observational data. The researcher listed an observational rubric category and its sub-headings. Once the sub-headings were listed below each category, the researcher looked for evidence and overlaps between the sub-heading and the observational data collected. This coding process allowed the researcher to look for deeper connections and overlaps between the independent and dependent variables. All data collected remained confidential throughout the data collection and data analysis process.

The researcher then looked for a relationship between teaching and learning seeking to answer the question: How can a concise framework of learning be designed and developed that accommodates learning style principles, constructivist perspectives on learning, and instructional design principles? All interpretations of the data were re-analyzed when the researcher reflected on the data being observed.

The procedure for qualitative data analysis was described by Marshall and Rossman (1989) as a process that brings order, structure and meaning to the mass of collected data. After the coding completed, the responses describing the same idea were grouped together and ascribed names. This process was called categorizing (Strauss & Corbin, 1990). The procedure for data analysis thus was undergone a number of processes: data reduction, and coding of data, developing a framework for the data analysis, content analysis, units of analysis and data classification.

The data collected qualitatively, that is, through observation (field notes), focus group interviews, key informant interviews and integrated design frame works, were analyzed through the processes of coding, categorizing and reduction- labeling discrete incidents, events or anything that represents a phenomenon (Creswell, 1994).

Data Reduction and Coding

Data undergoes a number of processes during the process of analysis. In view of this, the first step was the coding and categorizing of data. Miles and Huberman (1994) refer to this as the process of data reduction. Data reduction refers to the process of selecting, focusing, and simplifying and abstracting the data collected (1990). In this study, the data-generated categories (Variables) and sub-categories clustered around the three aspects of the study: constructivist learning perspectives, instructional design and learning styles preferences.

The Trustworthiness of the Research Findings

It is significant that qualitative methods ensure the quality of the research findings. It is referred as trustworthiness of the research (Krefting, 1991). According to the ESTEEM manual (Burry-Stock, 1995), one way to control for inherent measurement problems and increase the validity of the performance measure is to standardize the procedure for collecting data. To obtain, analyze, and provide information for making a decision on the behavior of the teacher, there must be a consistent procedure used across all instruments that result in accurate sound decisions. The ESTEEM provides the researcher with five steps to ensure a valid performance using a standardized procedure for data collection. The five steps to a Valid Performance Evaluation (Burry-Stock, 1995) are:

1. observing the data source;
2. recording objective and accurate data;
3. retrieving the performance using some form of record;
4. analyzing/scoring the observation by comparing the record from the data source to a specific criterion (criteria); and
5. evaluating the observed performance using the information from the analysis completed in step four.

Similarly, the KLSI has distinct graphic projection and statistical measure in a sequence of steps to identify the particular learning style preferences of learner. This ensures the valid results of the learning styles.

Lincoln and Guba (1985) state that the criteria for trustworthiness include: credibility, applicability, dependability and confirmability, and are constructed parallel to the conventional criteria of internal and external validity, reliability and neutrality. Thus, rigor in research can also be based on Krefting's model comprising four aspects of trustworthiness relevant to both quantitative and qualitative studies, namely truth value, applicability, consistency and neutrality. Table 3.6 summarizes the comparative discussion of criteria by research approach.

Table 3.6

Comparison of Criteria by Research Approach adapted from Krefting, 1991

Criterion	Qualitative Approach	Quantitative Approach
Truth Value	Credibility	Internal Validity
Applicability	Transferability	External Validity
Consistency	Dependability	Reliability
Neutrality	Confirmability	Objectivity

The trustworthiness of this research was established through credibility, transferability, dependability and confirmability and includes triangulation.

The Credibility of the Research Findings

Credibility in qualitative research is defined as the extent to which the data and data analysis are believable and trustworthy. In this research study, the credibility of the research findings was maintained through referential adequacy, a process whereby various documents, official records, pictures and transcripts of interviews and focus group discussions as well as field notes collected during the study. They were made available for future reference and thus establish referential adequacy for this research project. Triangulation was used to improve the credibility of the study by comparing multiple sources of data used to assess the same variables. Prolonged engagement enhanced credibility by providing the researcher the opportunity to develop a trusting relationship with the research participants. Peer debriefing enhanced the credibility by soliciting additional data collection and analysis. Member checks also enhanced credibility of the findings by subjecting them to the additional interpretations and opinions of the study participants. Interpretations were reported back to the participants to see if these interpretations made sense to them. This process enhanced credibility and provided another opportunity to incorporate the teacher's perspective and experience into the analysis process.

Peer Debriefing. One of the science teachers at the sample school was asked to serve as a peer debriefer by co-analyzing all concept maps completed by the students in the science class. He is an expert in the field of secondary level science education. Although an expert in the field of science education, the teacher had no experience working with the ESTEEM concept mapping rubric. He was asked to listen to the analysis the researcher was in the process of developing and asked for feedback. Once this process was completed, the teacher coded the student concept maps using the ESTEEM manual and his scores were compared to the researcher's scores for consistency.

Member Checks. The science teacher was asked to examine the chain of evidence collected by the researcher to see if the analysis/interpretations made sense to him, as a verification of interpretations. The researcher went back to the educators researched or interviewed, at the completion of the study, and asked each participant if the researcher was accurate or needed correction or elaboration on the data as it was collected and interpreted.

The Transferability of the Findings

Research findings are transferable when they fit into contexts outside the study situation. Lincoln and Guba (1985) define transferability as the extent to which the research findings from one research study can be applied into other contexts or to other participants. In this study, the participants were secondary level high school students whose curriculum content in science and learning mode were similar to other schools. They all face the same national School Leaving Certificate Examination for learning assessment. The extent to which the sample class represented all secondary level students enrolled in English medium schools was considerable.

The Dependability of the Findings

Dependability refers to whether the findings of the research would be consistent if the studies are repeated with the similar subjects in a similar context (Krefting, 1991). Seale (1999) maintains that dependability can be achieved through auditing, which consist of the researcher's documentation of data, methods and decision made during a thesis as well as its end products. In this research, replicability was confirmed when the saturation point of the data had been reached. It can be said with the certain degree of certainty that if the same study was conducted several times, there would be a greater possibility that the same results would be achieved. Prolonged engagement also enhanced dependability.

Audit Trail

The decisions and actions of the researcher were documented from initiation through study completion using the ESTEEM. This use of the ESTEEM provided an audit trail of the study. The audit trail was a record of the research process, as well as the decisions and choices made by the researcher. One of the curriculum experts, the ex-director general of Curriculum Development Centre of Nepal, served as an external auditor by reviewing the data collection and analysis process through the audit trail.

Research Bias

The issue of bias in qualitative research is an important one and demands special attention and discussion in any qualitative research study. This study, conducted as a constructivist-based exploration, presents an analysis of the relationship between constructivist teaching and the students' understanding of science. While researcher bias and subjectivity are commonly understood as inevitable by most qualitative researchers, the researcher conducted a qualitative research study so that the teachers and students involved were comfortable with the idea of someone observing, interviewing, and note taking in a way that is not value-neutral. This helped minimize bias in the data.

Because it is not possible to eliminate the researcher's bias, it is important to understand his background. The researcher in this study is a 40 year old male. He has graduation in science and sociology and in education. He taught for 15 years at the secondary level school. The researcher was a lead trainer of teachers teaching science in Nepalese schools. He worked as an active participant in the iearn science, environment and mathematics training of six weeks hosted by iEARN USA. The researcher served on training of peace education, right to education, good school governance and social auditing in educational institutions, and involved in developing text books and reference books of formal and non formal education for different age level groups. Recently, the researcher had led the team of researchers to evaluate the 17 years of Bhutanese Refugee Education Program - one of the largest refugee education programs for emergencies in the world.

The researcher returned to Kathmandu University to pursue an M Phil and a doctorate degree in educational leadership to find answers related to how instructional strategies, pedagogy, and student understanding overlap with curriculum. During his graduate studies, the researcher first became familiar with constructivism and its use in science teaching through a course called Foundation of Education. The researcher began the study familiar with constructivism and best practices for science education.

The researcher entered the school environment in sample schools un-aware of the depth of constructivism evident in the science teacher's teaching. Having a background as a secondary level school science teacher, the researcher understood the level of the students and the science content adopted by the school district. During the research study, the researcher found himself looking at different perspectives of constructivist-based teaching, student's conceptual understanding of the science content, how students interact in a ninth grade science classroom, and how constructivist-based teaching may work at this level. This study results is a rich description that presents a clear audit trail so the reader can construct his or her own meanings of the researcher's discoveries.

The Confirmability of the Findings

Confirmability is the degree to which the research findings can be confirmed by another researcher (Krefting, 1991). De Vos (1998) asserts that confirmability refers to the degree to which the findings are a function solely of the informants and conditions of research and not of other biases, motivation and perspectives. In qualitative research the value of findings increases when the distance between the researcher and the informants decrease. In the context of this study, transcription of raw data, that is, ESTEEM, KLSI and basic learning skills questionnaires were used. The narratives, interviews, analysis of and integrated design framework based on the learning design were given to the external, independent research specialist to determine whether the findings were in accordance with the raw data of the research.

Triangulation

One of the most important ways to improve the trustworthiness of the research findings is by triangulation (Tellis, 1997). In view of this, Fielding and Schreier (2001) distinguished three meaning to triangulation:

1. Triangulation as the mutual validation of results obtained on the basis of different methods (the validity model),
2. Triangulation as a means toward obtaining a larger, more complete picture of the phenomenon under study (the complementary model), and
3. Triangulation indicating a combination of methods which is necessary in order to gain any picture of the relevant phenomenon at all (the trigonometry model).

Multiple sources of data and data collection strategies were used to triangulate the findings of this study. Multiple sources of data included the science teachers, students, headteachers, and the researcher. The multiple data collection strategies used in this study included: observational evidence including field notes, lesson plans, and other teaching materials, interviews of the teacher, students, and headteachers; inventories completed by the teachers and students; and samples of student work and other achievements of student learning. This process of triangulation ensured that all patterns and trends were supported by multiple sources collected through multiple strategies enhancing the credibility of the findings.

During the interview process with the students, the researcher asked the same set of questions, in the same order, using the same words to all interviewees. The structured interviews were convenient for triangulating different interviewees' answers to the same questions. The researcher used different types of interview questions for the headteachers, students, and the teachers. Interviewing different individuals in this exploratory study was important because the data collected used different methods to show the same pattern. This process enhanced the credibility of the patterns that emerged and became a useful tool for this exploratory study.

Integrating Qualitative and Quantitative Data

Skillfully integrating quantitative and qualitative data can greatly increase the richness of information by providing credible estimates of data as well as an explanation of the processes and interventions that yielded research outcomes. Although quantitative and qualitative evaluations can proceed in parallel with findings compared and combined during analysis, the greatest value-added from using the two methods is realized through an iterative approach where preliminary results from one type of data collection are explicitly intended to inform the design of a future round of data collection.

Using both forms of data allows researchers to simultaneously generalize results from a sample to a population, as well as to gain a deeper understanding of the phenomenon of interest. Using mixed methods in research and evaluation offers methodological and practical advantages. From the practical perspective, mixed methods research yield context rich data valued by the teacher and, at the same time, allow aggregating and summarizing data. High quality research, which command respect and attention from broad audiences, requires multiple methods (Wilson, Floden, & Ferrini-Mundy, 2002). Researchers can also test theoretical models and modify them based on participant feedback.

Collins et.al. (2006) identified four rationales for conducting mixed methods research: participant enrichment (mixing quantitative and qualitative research to optimize the sample of participants, ensuring that each participant selected is appropriate for inclusion), instrument fidelity (assessing the appropriateness and/or utility of existing instruments, and creating new instruments), treatment integrity (assessing fidelity or intervention), and significance enhancement (facilitating thickness and richness of data, augmenting interpretation and usefulness of findings).

This research was designed to study the same phenomenon (triangulation), the elaboration of quantitative results with qualitative results (complementarity) and the using of qualitative findings to help inform the quantitative method (development). In this case focus group discussions and constructivist interviews provided a better understanding of the student teachers' perceptions of their student teaching experiences.

The Role of the Self

The researcher plays an important role in the production and interpretation of qualitative data and the identity, values and beliefs of the researcher can not be entirely removed from the research process. As a teacher of secondary level science and author of science text books, the researcher took a frame of reference that was based in pedagogy. From this point of departure, the researcher planned a theoretical framework for the design and managed the development of interactive learning tools from a constructivist perspective, in order to accommodate the learning styles of the students who were the participants of this study. In this frame of reference, the researcher's self played an important role in the analysis of the data.

Chapter Summary

This chapter has included the basic fundamentals of research methodology adopted on the study. All sampling strategies, data collection techniques, instruments, and techniques of data analysis and reduction were discussed in this chapter. The strategies for minimizing errors had also been elaborated along with the validity and reliability of the research. This inquiry employed an analytical framework for gaining insight into the way constructivist instructional design use when designing learning environments for learners. The diagram illustrated in figure 3.3serves as a summary of the research design and methods:

Figure 3.3: Summary of Research Design and Methods

Problem Statement: How can a concise framework of learning system be designed and developed that accommodates learning style, constructivist perspectives on learning, and instructional design principles?

The next chapter presents the findings of the research in detail.

CHAPTER IV

HOW SECONDARY LEVEL LEARNERS LEARN SCIENCE?

Introduction

The previous chapter explained the methodological approach that I followed during the study. This chapter begins with the presentation of overall educational setting of the country and a brief educational status. The chapter also includes the detailed physical settings of the three categories of schools namely the trust school, the institutional school and the government funded community managed schools. This chapter mainly focuses on a detailed analysis of the perceptions and experiences of science students of the secondary schools. In addition, the chapter consists of the teachers' perceptions on the implementation of the constructivist strategies in teaching learning science. In this connection, this chapter provides an explicit account of the outcomes of the research in accordance to the criteria specified and the designed process established. The findings of the study are organized in this chapter in my attempt to seek the answer of the research question, "How is the constructivist learning theory and the instructional design principles incorporated in classroom instruction of Nepalese schools?"

Searching the Constructivists

In search of the constructivist teachers for the purpose of this study, I organized five workshops throughout the country focusing on the densely populated districts where the performance of the schools is found better in comparison to other districts. The selected districts for the purpose were Jhapa, Nuwakot, Sindhuli, Pokhara, Bhaktapur, Lalitpur and Kathmandu. Altogether 182 representative teachers participated one from each schools in the workshops. They all were exposed with the constructivist approach of learning in the classrooms. The workshop was about the different aspects of learning design practices of constructivist learning. There was demonstration of facilitating the learning process, content specific pedagogy related to student understanding, context specific pedagogy related to constructivist teaching, content knowledge, assessment of constructivist learning practice and learning outcomes with special reference to science learning. During workshops, the ways of learning science of all the participants were observed and thereafter, the participants were given survey forms to describe their way of teaching. Each participant in the workshop was observed using the Expert Science Teaching Educational Evaluation Model (ESTEEM) (Burry-Stock, 1995).

All the participant teachers attempted the response of the constructivist learning survey form (the detail is in the annex IX). Among them, three teachers were identified as a strong example of constructivist-based teaching. These three teachers were selected based on the highest score they obtained on the survey and were one from each category of community based secondary schools, trust schools and privately managed institutional schools. I studied the schools of these three teachers who were recognized as constructivist teachers. The details of the schools of those teachers are explained as below.

Constructivist Learning Environment at SOS Herman Gmiener School

One of the selected teachers was from the trust school namely Herman Gmiener School located in Sanothimi, Bhaktapur. The School features a structured academic program with opportunities to explore science, culture and the arts. SOS's music program features instrumental and vocal music classes. Computer classes provide a strong foundation for all students. Technology is integrated throughout the school program. Students who experience difficulty in language, science or math, are placed in an intervention to assist them in their academic advancement (SOS vision, 2008). Students are admitted to SOS Herman Gmiener School in accordance to the entrance exam from applications received all across the country. The headteacher of the school reveals that teachers at SOS work together with students and parents to ensure that the students are successful in academic and social experiences. The administrators encourage the teachers to become a part of all social interactions in the classroom and outside as well.

The Mission Statement of SOS Herman Gmiener School is:

> "We build families for children in need, we help them shape their own features, and we share them in the development of their communities."
> (SOS Vision, 2008)

As I walked down the sidewalk at the front of the school, there were flowers on the sidewalk. I approached the front doors of the building and observed assembly pray to begin the class. As I entered the school for the first time, he observed concrete block walls painted some time ago. There were some posters of students' creation that were hanging on the walls. The lighting of classrooms was bright. I felt a warm positive environment filled with the roar of grade nine students. I often observed students spilling and dropping papers, slamming books, and stepping on pencils. Teachers passed me in the hallway asking who I was consulting for, did I know how to get to where he was going, did I need any help, and what grade level was I teaching for that day. Many times teachers looked right at me, pointed to the office and said,

> "That is where you need to go, right down there."

As a former secondary level school teacher, this was home; a place I once spent so much time trying to help so many students. When asked about the school, the principal explained,

> "We are SOS schools. We have school here with a great group of kids."

The school's librarian commented on the school and her role within the school as,

> "The building, its resources and these kids are really great. We have issues like anyone else but this was a great place for me to come out of retirement for. I am glad to be doing what it is I am doing right now in my life."

SOS has students who apply to come to this school, many of the students come from a wide variety of backgrounds and scattered locations throughout the valley. Overall the atmosphere at Herman Gmiener felt warm, exciting, adventurous, and safe. The school appeared to have its ups and downs when it came to student cooperation, discipline issues, teacher interactions, building improvements, and other issues that many other secondary level schools encounter. SOS appeared to have a non threatening environment, which provided teachers and students the positive opportunity to grow in education through cooperation, determination, dedication and satisfaction. Teachers in SOS expressed they still take work home, find little time for lunch, wait in line to make copies, are limited on their budgets and supplies, would like to see more interaction with each other without feeling overwhelmed, and would like the opportunity to see all children succeed.

During this study, I found the teachers were very conscious for students even outside from the classroom. The teachers used to stand in the hallways to ensure safe passage of the students within the intervals of the class hours. Students used to show their respects to teachers and within them as well. Students' performance works could be found displayed throughout the hallways of the school. Photographs of student's activities were placed in locked glass cases. In my observation from December 20, 2008 to February 25, 2009, the science teachers were in casual dresses but all students were found in uniform.

The classroom of the science teacher was a unique one. The room had eight rows of four desks in each row in the middle of the room that faced forward to the white board and were surrounded by windows in the walls. The laboratory was complete with sufficient materials to use. There was internet access for the computer in library which gave students the opportunity to use the internet for additional technology support.

I observed the science teacher had a demonstration lab table in front of the room where he could conduct demonstrations, access the computer to take role in his audio visual classroom, write on a wide white board, has access to water for lab work and control the climate in the classroom. The science teacher had many posters of science experiments hanging on the wall from students as well as current projects being constructed in the classroom. These experiments ranged from constructed solar systems that operate on light and many other items students could observe while in his classroom.

The staff room had a wide variety of supplies that both teachers shared, provided access to more space. Teachers did their grading and prepare for teaching in this room.

In the 2008 – 2009, there were 82 students who participated on the science teacher's classroom in grade IX. There was a diverse group of students in each of the classes, including different ethnic groups. During this year, the science teacher taught a dual science curriculum with a first day physics, second day chemistry class, third day biology, and fourth day astronomy and geology.

Constructivist Physical Setting at Himalaya Higher Secondary School

This school is another sample school selected from the category of institutional schools, located in Koteshwor, Kathmandu. The school is almost on the equidistant from three cities Bhaktapur, Lalitpur and Kathmandu. Students are selected for the admission by entrance exam. The School features academic programs with opportunities to explore business, and culture. Teachers integrate this theme throughout their instruction, making connections between subject-area, content and the contexts. According to the headteacher, computer classes provide a strong foundation for all students. Technology is integrated throughout the school program. The exploratory offerings are rounded out with classes in physical education, the visual arts, and science. Students who experienced difficulty in language, science or math, are placed in an intervention to assist them in their academic advancement and there is also boarding facilities for the students (The Himalayan, 2008).

I often observed that the school had new audiovisual science classroom, computer lab and program halls. Students were respectful to staff and one another as they passed from one classroom to the next. Photographs of student's activities are placed in locked glass cases, and records of student athletics were presented in front of the public meeting rooms from years past to present. Students and teachers wear uniform at Himalaya Higher Secondary School. While being observed from December 20, 2008 to February 25, 2009, the science teachers usually wore casual dresses. During the observed period, all students wore dresses and repeated the same outfit for the first three days of the week. They wore house-wise dresses for the remaining days.

As I walked up to the school for the first time, there were quotations, notices on the side walls. I approached the front doors of the building and observed assembly pray to begin the class. There were some posters of students' creation that were hanging on the walls. The lighting of classrooms was bright. I felt a warm positive environment filled with the roar of grade nine students. I saw groups of students talking about their fashion, dress up and their current activities. I noticed students smiling, moving in packs, groups of two or three, and making turns.

Both the headteacher and assistant headteacher were busy, however they were friendly to. When I asked about the school's objective, the principal explained,

> "Our motto is - do good and be good. The building, its resources and these kids are really great. We have issues like anyone else but this was a great place for me to serve the people. I am glad to be doing what it is I am doing right now in my life."

Students come from a wide variety of backgrounds and scattered locations throughout the valley. Overall the atmosphere at Himalaya Higher Secondary School felt peaceful, child centered, and safe. The school appeared to be committed in student cooperation, discipline issues, teacher interactions, building improvements, and other issues that many other institutional higher secondary schools encounter. The school appeared to have a non threatening environment, which provided teachers and students the positive opportunity to grow in education through cooperation, determination, dedication and satisfaction. According to the headteacher, the community that surrounds the school provides the students the opportunity to grow and maintain positive values outside of the school boundaries. Teachers expressed they still take work home, and are limited on their budgets and supplies, would like to see more interaction with each other, and would like the opportunity to see all children succeed.

So far the classroom environment was concerned; the classroom of the science teacher was student-friendly. The room had three rows of five desks in each row in the middle of the room that face forward to the black board and was surrounded by windows in the walls. The laboratory was full of materials and chemicals to use. There was internet access for the computer in laboratory which gives students the opportunity to use the internet for additional technology support. I observed the science teacher had a demonstration table in the front of the room where he could display audio-visuals, write on a black board, have access to water for lab work and control the climate in the classroom. There were many posters of science experiments and current projects hanging on the walls of the classroom. In the 2008/2009 academic year, there were 36 students in grade nine who participated on the science teacher's classroom.

Teaching Learning Environment at Tyoud Secondary School

This government funded community school was the third sample school selected from the public category located at Ason, the heart of the capital city, Kathmandu. The school is on the densely populated area of the capital near Thamel. Though the school is funded by the government, community has managed the school. This school is one of the few community schools where the medium of instruction is English.

I often observed that the school was kept clean. Students were respectful to staff and one another. Photographs of student's activities were placed in walls of the rooms. While being observed, the science teachers usually wore casual dresses. During the observed period, all students wore uniform but repeated the same outfit for the week. Most of the students were from the low economic status background.

The lighting of classrooms was not sufficient as the building was surrounded by other tall houses. I felt a good environment filled with the roar of grade nine students. I noticed students smiling, moving in packs, groups of two or three, and making turns. In the 2008 – 2009, there were 56 students who participated on the science teacher's classroom in grade IX.

According to the headteacher, students come from a wide variety of backgrounds and scattered locations. Overall the atmosphere at the school felt peaceful, child centered, and safe. The school appeared to be committed in student cooperation, discipline issues, teacher interactions, building improvements, and other issues that many other higher secondary level schools encounter. The school appeared to have a non threatening environment, which provided teachers and students the positive opportunity to grow in education through cooperation, determination, dedication and satisfaction. Teachers in an interview expressed that they still take work home, and are limited on their budgets and supplies, would like to see more interaction with each other, and would like the opportunity to see all children succeed.

The classroom of the science teacher was quite student friendly. The room had two rows of seven desks in each row in the middle of the room that faced forwards the black board. The laboratory had some materials and chemicals to use. There was no internet access for the computer in laboratory to use the internet for additional technology support. I observed that the science teacher had a demonstration table in the front of the room where he could conduct demonstrations, write on a black board, and control the climate in the classroom. The science teacher was found trained by the government program for child-friendly teaching.

Table 4.1 shows the constructivists' similarity and differences from the constructional point of view as compared to the theoretically prescribed frame of understanding.

Table 4.1

Constructional Similarities and Dissimilarities

Indicators	CS	TS	IS	Theoretically Prescribed Frame of Understanding
Constructional similarity	Medium of instruction, national curriculum	Medium of instruction, national curriculum	Medium of instruction, national curriculum	Individualized curriculum, learner favored language of instruction
Constructional dissimilarity	Large number of students, teacher centered classroom structure	Student centered classroom structure, small population size	Small room and teacher centric structure	Learner friendly classroom structure, ill structured versus well structured domain

The theoretically prescribed frame of understanding indicated that individualized curriculum and learner favored language of instruction should be the basic ground of similarity among the school classroom and learner friendly classroom structure including ill structured as well as well structured domain may be in favor of constructivist learning science. However, among the sample schools, medium of instruction and national curriculum framework used were same. On the other hand, there were large number of students in a class and teacher centered structured classroom in sample community school, student centered classroom structure and comparatively small sized population in trust school but small classroom and teacher centric structure in institutional school.

Learning Design Practices from Constructivist Perspective

After presenting the brief scenario of research milieu, I explain how constructionist perspectives in learning design practices function in the study area hereafter. As explained earlier in introduction chapter, the existing situations of the incorporation of constructivist learning theory and the instructional design principles in classroom instruction of Nepalese schools were the major concerns of the study. Information was generated and analyzed using observational evidence including field notes of classroom observations, the Expert Science Teaching Educational Evaluation Model (ESTEEM) classroom observation rubric, lesson plans and other teaching resources; interviews of the teachers and participating students; survey responses from the teachers; and achievements of student learning including exam scores and portfolio assessment. The study was concentrated around four major units of science learning: Electricity and Magnetism, Chemical Bonding, Taxonomy of plants, and Atmosphere. Interviews were taken once at the beginning of the study and before and after the observation of the class. The teaching practices assessment inventory was used to triangulate the data observed from the observation and interviews based on the constructivist perspective of the ESTEEM instruments. The analysis attempted to identify how constructivist-based teaching was being used in the secondary level classrooms of the sample schools, and how constructivist-based teaching helped the students understand science.

I used the ESTEEM Observation Rubric's four major categories to assess constructivist teaching. Among these four categories, observation, interview and the teaching practice assessment facilitating the learning process from constructivist perspective was the first category described with its five components: teacher as a facilitator, student engagement in activities, student engagement in experience, novelty and text book dependency. The second category describing the constructivist nature of learning was Content-Specific Pedagogy Related to Student Understanding which was further described under student conceptual understanding, student relevance of the lesson with respect to student experiences outside the classroom, variation of teaching methods, higher order of thinking skills, integration of content and process skills, and connection of content and evidence. Similarly, the third category was Context-Specific Pedagogy Related to Teaching including resolution of misperceptions, teacher student relationships, and modifications for student understanding. The fourth category was Content-Knowledge which was described within the indicators such as use of exemplars, coherent science experiences (lessons), balance between depth and comprehensiveness and accurate content. I also examined observational data through the assessment of teaching learning practice using the sheltered instructional observational protocol model and the classroom learning in science inventory. Finally, the learning outcomes were assessed through the records of District Level Examination (DLE) and the student outcome assessment rubric as well as concept mapping rubric. The following theme describes the learning design practices from the constructivist perspective as illustrated from the study.

Facilitating the Learning Process from a Constructivist Perspective

During the observation and interview, the different levels of constructivist practices were apparent in connection with the learning facilitation process of constructivist perspective. I attempted to examine the extent of facilitation by the teacher whether teacher-student learning experience is a partnership or teacher centered or student centered. Similarly, level of student engagement in initiating examples, asking questions, and suggesting and implementing activities throughout the lesson was measured in second component. The third component was about the physical and mental involvement of students in learning. The fourth measure was about newness, divergence, or curiosity used to motivate learning and fifth indicator was measured to what extents the teacher depend on the text book. Table 4.2

describes the range of the learning practices of the teachers in the three categories of the schools.

Table 4.2

Facilitating the Learning Process from a Constructivist Perspective

Variables	Not at all skilled ← (1)→	Intermediate ← (3)→	Highly Skilled ← (5)→
Teacher as a facilitator		CS IS	TS
Student Engagement in Activities		TS CS	IS
Student Engagement in Experience	CS IS		TS
Novelty		CS IS	TS
Text Book Dependency	CS IS		TS
Average Rank		CS IS	TS

CS: Community School, IS: Institutional School, TS: Trust School

As noted in table 4.2, while concerning about Teacher as a Facilitator, I observed the science teacher as part of the learning process at all times in the trust school. Students appeared to feel comfortable asking the teachers' advice. But many times I observed students stopping before they asked because they knew the teachers would not give them the direct answer to their question. In comparison to the trust school, the institutional and the community school were found weak in student engagement in experience and in text book dependency. I often noticed that students were given every opportunity to look around to see what other students may be doing in the classroom. I often observed the class working as a team. The teacher did not try to fill them with pre-determined knowledge. The observation protocol I (Annex IX) demonstrates the visualization of the class in highest ranked constructivist classroom in the trust school among the three categories of sample schools.

The facilitation practice demonstrated in the trust school was also supported by evidence from the interviews of students, teachers, and headteachers. When the students were asked to tell me about the teacher, one of the students interviewed from the trust school, said,

> “Wonderful! I still don’t know through what method he teaches, he teaches relating something to another and how they come together. Like, when he says - do some activities, but not really telling us exactly what to look up and where to go. He says as if we are investigators in some extent.”

Another student explained that he didn’t lecture from a place; he came around their desks to see how the things were going with them. The students in the highest ranked constructivist science classroom of the trust school were responsible for their own learning experiences. The science teacher of the trust school praised students constantly on what it was they were doing at that very moment. It can be claimed that the constructivist teacher is best fit for being a facilitator rather than instructor.

While considering the Engagement of Students in Different Activities, the students of the institutional school were observed to be actively engaged in initiating examples, asking questions, and suggesting and implementing activities throughout the class hour. In the Electricity and Magnetism, Taxonomy of Plants, Chemical Bonding, and Atmosphere units, the teacher of the trust school encouraged his students to test their own ideas by answering their own questions, exploring and reasoning, conducting a trial and error, and discussing with one another their guesses, predictions, explanations, and questions. The teacher did not answer direct questioning from his students. They had to examine the evidence. This evidence was supported by interaction with the students. One student described her activities and engagement as,

> "If we have a question, we may ask the teacher or we may ask among us. The teacher does not answer our questions directly. He flips the question around and diverts our questions to what we already know. When we ask why the sky is blue, he responds - what is in the sky? He goes back to something what he has taught and what we have learnt earlier. He always refers back to learned ones."

In this connection, a response from a second student was, "The teacher teaches us to expand on what we know. We have to make suggestions on what needs to be done to modify our laboratory activity. It helps us to memorize what we know. I learn much when he teaches." The teacher of the institutional school activated students' prior knowledge through a questioning routine, brainstorming and predicting outcomes. Students were given an ample amount of time to discuss in groups what they knew about new concepts. During a fifteen minute observation of the taxonomy unit, the students were asked to come up with their own ideas about how to classify the plants that could help to study all the plants of the surroundings. Two female students developed comparative charts of plants to include similar plants in one group. These two students constructed their own ideas regarding flowering and non flowering plants. The teacher encouraged students to examine and interpret the evidence in order to test their own ideas and answer their own questions. In contrast, some of the trust and the community schools have different practices. The students were partially engaged in initiating examples, asking questions at time during the lesson. It can be claimed from the study that involvement of students in different classroom activities enhanced the constructivist practice of learning in the class.

In case of Student Engagement in Experience, the students in the trust school were actively engaged in experiences both physically and mentally, on a constant basis. All observed units were taught from a hands-on perspective in science class and there was a level of student ownership from all constructed experiences. The excerpt (Annex IX) from the ESTEEM rubric used by me to record field notes further verified the student engagement in experience. There was contradiction of observation and the interview taken from the students of institutional school. When students of the institutional school were asked what their favorite subject was, science was mentioned by four students because they got to do a lot more, and it was more hands on. They felt that they did not have to just sit there and read all day. One student described his experiences with the teacher and his teaching as,

> "He is not the type of teacher who just writes on the board. We have fun with what we do. We rarely work alone. It is always like a group effort."

The other student said, "He likes to have us play while learning. We interact. Other teachers don't do that at all." Another student further explained,

> "He likes to joke a lot. He makes everybody laugh. He makes science fun, not like our father's science teacher who makes everyone do rote learning. Rote learning is boring."

In observation and in interview, the students of the science class of community school and the institutional school were found seldom engaged in the experiences. They mostly involved on rote learning and note taking in the classes. I claimed that the trust school is best suited for engaging students in experience. All lessons observed, in the trust school, were found consistently using novelty, newness, divergence, and curiosity to motivate learning. The observation was also supported by interview taken with the colleague of the science teacher of the trust school. According to him,

> "The science teacher teaches uniquely. He asks us to find the holistic scenario of the topic. He doesn't give us the overall concept at first. He gives us a glimpse and ask us to figure out what they have in common to come up with the exact concept that we need to explore. He gives us

> the direction but never provide the guidance to get there. He wants us to find out for ourselves. In the end, no matter what route we follow, we reach the destination."

Likewise, the institutional and the community school science teachers sometimes used novelty, newness, divergence, or curiosity to motivate learning. I found that trust schools have best described in practicing novelty.

So far the Textbook Dependency is concerned, the teacher did not show a dependency on a textbook for student learning in the trust school. I observed that students learned through the materials and activities presented to them. When the teacher was asked about textbooks in his classroom, he responded,

> "I do not believe in rote learning, and students need to construct or develop what they understand it to be. Textbooks and science lessons in books are someone else's construction of that knowledge. Readymade printed books sometimes can be a guideline for a teacher. However, students' knowledge should not be constructed from these books alone. Students need to explore within their own minds as to what the lesson/unit means to them."

The teacher provided a variety of alternative sources for new information both through written materials and experts. The evidence of less text book dependency of the science teacher of the trust school was further supported by the response of the students. One student said, "No textbook reading as the teacher wants it to be interesting and books are hard to understand and boring as well." Another student described their class as, "The teacher doesn't make us read books. It is hard for me to stay focused than just reading the text. I don't like to read." The next student added, "How much to depend on myself, come up with ideas by myself, instead of depending on other people or books." A student from Thimi explained, "Last year we focused on book study only. It does not help me. It is different than experiments in the class. Books only tell us what someone else knows not what we know them."

The result from the observation of the science teacher's class in the trust school as illustrated in annex IX showed that the teacher does not depend on the text books to present the lesson. Teacher and students develop own content materials for their needs. On the other hand, the science teachers from the community and the institutional school were solely depending on the text book to present the lesson. The teachers made no modifications with the students. The textbook that was available in the classroom was titled 'Learning Science' of which one of the co-authors was me myself. The teacher felt that it was one of the reliable textbooks for kids to see another example of the content they were studying. But there were not enough reference books to send home with each student.

Table 4.3 describes the constructivists' similarity and differences from the learning facilitation point of view as compared to the theoretically prescribed frame of understanding.

Table 4.3

Comparison of Learning Design in Sample Schools

Indicators	CS	TS	IS	Theoretically Prescribed Learning Facilitation
Facilitation similarity	Teacher dominance and more text book dependent	Teacher dominance and more text book dependent	Teacher dominance and more text book dependent	Teacher as a facilitator, and less text book dependency

Facilitation dissimilarity	Less engagement in activities and more in experience and less novelty	More engagement in activities and in experience and novelty	More engagement in activities and less in experience and novelty	Student engagement in activities and in experience, and Novelty

As noted in table 4.3, the theoretically prescribed frame of understanding indicated that teacher's role should be as facilitator and less text book dependent where as there should be more student engagement in activities and in experience as well as novelty. All the sample schools were having teacher dominance and more text book dependence. However, among the sample schools, there was less engagement in activities and more in experience and less novelty in sample community school, more in trust school but more engagement in activities and less in experience and novelty in institutional school.

After the analysis of the results, it can be stated that the community and the institutional school teachers are more text book dependable which is against the constructivist practice in the class. It can be claimed that the teacher in the trust school is best described on facilitating the learning process from the constructivist perspective in comparison to the institutional and the community schools.

Content-Specific Pedagogy Related to Student Understanding

While considering the content specific pedagogy related to student understanding, the different levels of constructivist practices were recognized in the three categories of the school. The student conceptual understanding was judged by the time interval of focusing on student activities understanding the concept. Student relevance was measured the level of lesson related to student experiences outside the classroom. Variation of teaching methods, the integration of content and process skills as well as connection of content and evidence were comparatively rated in the three categories of the sample schools. Table 4.4 describes the range of the teacher practices of content specific pedagogy related to student understanding in the schools.

Table 4.4

Content Specific Pedagogy Related to Student Understanding

Variables	Not at all skilled ← (1)→	Intermediate ← (3)→	Highly Skilled ← (5)→
Student Conceptual Understanding	CS	TS	IS
Student Relevance	IS	TS	CS
Variation of Teaching Methods		CS IS	TS
Higher Order Thinking Skills	CS IS		TS
Integration of Content and Process Skills	CS IS		TS
Connection of Content and Evidence	TS IS		CS
Average Rank		IS CS TS	

CS: Community School, IS: Institutional School, TS: Trust School

As noted in table 4.4, in case of highest ranked science teacher's class from the institutional school, all units observed were focused on activities that related to Student Conceptual Understanding. The teacher planned his units to match the appropriate level of his students and their educational background. He used student ideas, experiences, and interests to drive his units. He built understanding through his planned activities and he reinforced understanding through questions and discussions. He also adapted his lessons for his students. The teacher continued the activities until students could demonstrate their understanding of the concept. Annex IX illustrates the sample of role play observed by me during the class observation.

In the institutional school, students were interviewed on their understanding of the science concepts being taught to verify the rating of the rubric. One replied that science gave him the opportunity to think. When students were interviewed in a group they expressed their views as,

> "I learn this way better than any other class. You get to talk other people around you to find out what they are thinking. If I don't get it, the teacher may direct a little so that we can move further. He lets us think about it first. I speak two languages: Nepali and Newari so I am learning it two ways. This helps us think instead of telling us how to think. We want to learn how he teaches. He makes it so interesting."

The expression of the students demonstrated that variation of the methods, language diversity were added advantages in constructivist learning. In this connection, one of the students was asked separately about their understanding of science and he replied,

> "The teacher does not teach as much as other teachers, this is my first time with physics, I like it. The teacher makes it fun and interesting. The strategies he chooses to do make it interesting."

When students were asked to tell the interviewer about what concepts they were learning right now, 68 students out of 82 were able to describe what they were currently learning about in the class. All of the lessons had something in common. They were linked together in a way that all students could understand. The teacher felt that if a teacher started with an experience, then by scaffolding onto the next experience, this allowed for some type of linking mechanism through each unit. In case of poorest rated community school science teacher's class, much of the time the lesson focused on activities that did not relate to student understanding of concepts. In overall, the result showed that students' conceptual understanding draws the attention of learner towards the learning activities and make the learner attentive.

In the least scoring institutional school, Student Relevancy focusing on the lesson related to student experiences outside the classroom was not a focus. However, the teacher from a community school, in the Chemical Bonds unit, the teacher related the themes to the students' everyday lives by asking them to examine what the words chemical and bond meant. There was never a clearly defined definition of the word chemical or bond in the classroom black board. The excerpt mentioned in Annex IX based on the ESTEEM rubric used by me to record field notes from the science classroom of the community school visualize the scenario. I found that all students were engaged through this entire process. Having students looked for themselves and constructed what they thought the differences between the bonds are, was the use of a constructivist teaching style.

The evidence of student relevancy was also recorded from the interview taken on the community school. In an interview with the students of the school teaching the chapter 'The Electricity and Magnetism', the students were asked what they learned from the class. A female student described her experience as, "I learnt a lot. To prepare circuits, basically open and closed circuits and knew how they flow electricity and stop." A male student from the same class described what he has learned in the class was,

> "I like what happens in the work and why they happen. How different things affect the resistance of current flow."

When asked his opinions of effective strategies to teach science, the teacher said, "Of course, we need to make the subject relevant so that we can keep students busy, occupied, and engaged." The result showed that student related activities enhance the learning and make the learning environment learner friendly.

In the trust school, I observed that the teacher used different methods to facilitate students' conceptual understanding. He used discussion, questions, brainstorming, experiments, student presentations, lecture, and demonstration. Each day in the science teacher's classroom was an event waiting to happen. The day began with what he wanted the students to be doing for that day. Many times it was a question such as, "What did you have for meal?" "How was your evening last night?" He liked to see where his students were as the day begun. The science teachers' long term lessons and units were examined. He planned out the weekly events in a school diary. He rarely used the annual planning manual. The teacher felt that a structured, school monitored, planning process does not allow freedom for the 'creative' planning. It controls too much of the person inside of us. The teacher felt that a good teacher can actually make adaptations to their original plans to take advantage of a 'teachable moment'.

I never observed the teacher delivering a formal lecture in the highest scoring trust school. All lessons were interactive and involved multiple modes of delivery. This information was also verified by the interview taken with the teacher in the trust school. The teacher explained that students had to feel it, see it, and touch it before they could start to understand it. He further said,

> "My students need a variety of learning activities in the classroom. If they perform activity, or if they perform some kind of experiment where they have to put activities together, they can see it and they have a visual picture to put together with words that they might be able to deal with it. I believe that I am giving them a basic break from their everyday routines in other classrooms where they sat and read from books or performed rote learning every day. The strategies have to be creative, interesting, changing, consistent, and powerful. Books offer little or none of those learning strategies."

The other teachers were found appreciative to the science teacher the way he organizes the learning activities and the way he delivers the lesson. In this connection, one of the teachers said,

> "I feel that I come in his class in relax mode and watch as something new is going to happen. I am in different classes each day where the teacher stands in front of the students all day and talks to them. If students look at the front of the room, they see is the black board, not the teacher. Contrary to a traditional class, he does not stand in front of the blackboard."

However, in the low scoring schools, the teachers used mostly single method to demonstrate the content i.e. lectures, discussion, questions, brainstorming, or experiment. From this study, it can be claimed that the constructivist learning environment can be enriched through the variation of teaching methods and learning activities in classroom.

The teacher in the trust school, consistently challenged students to use higher order thinking skills through their assigned tasks and his questioning skills. While observing in the lesson 'Electricity and Magnetism', students were never given direct instruction on how to construct their diagrams. I often observed students asking the teacher how to construct a circuit that could glow the bulb. I often observed students making minor adjustments to their diagrams. Students used problem solving and trial and error to construct the open and closed circuit. These students made adjustments and modifications to the circuits until one could be able to glow the bulb. The teacher from the trust school realized that students must be challenged and thought critically through each scientific process. He further added, "Students need to be blown away mentally every time they leave your class." In case of low scoring community school, the teacher did not move students through different cognitive levels to reach higher order thinking skills. Information generated from these observations revealed that consistently challenging students to use higher order thinking skills through their learning activities and assigned tasks followed by questioning skills enhance the constructivist learning practice.

In order to integrate the content and the process skills, the teacher from the trust school utilized the scientific processes of observing, predicting, communicating, experimenting, interpreting data, and forming conclusions when teaching each major science concepts in the unit. In the unit: Electricity and Magnetism, the teacher provided students with interactive practice environment to achieve difficult results. Students were encouraged by the teacher to exert maximum effort into their laboratory that modeled an electric bell process to accomplish school bell ringing. Students observed the audio visual clips, discussed what materials they would need, and predicted an outcome. I observed a group of four students whose materials consisted of wires, cells, bended iron rod, insulated solenoid wire and so on. Students discussed where the materials should go, constructed the electric bell and tested it. The students continued this process until their maximum effort produced a functional electric bell.

When I asked the teacher to explain what he planned to teach with the lesson, electricity and magnetism, he explained that the lesson was designed to come before the introduction of electric circuits and its components. He explained that each student needed to identify a problem, make a prediction, design an experiment, conduct the experiment, collect and interpret their data and state a conclusion. However, in the community and institutional schools, the teacher taught content without process or process without content. In essence, it can be claimed that the constructivist approach of learning emphasizes on teaching and learning through content and process hand in hand.

In case of Connection of Content Evidence, the teacher from the community school used evidence to build understanding of the concepts and expected students to do the same. I observed students working in groups on the Chemical Bonding. Students discussed how the words chemical bonds, ionic bonds, and hydrogen bonds connected. Through three separate observations, I observed students gluing white beads to the ends of straw pipes to demonstrate how bonds would react with one another. During these observations, the students went to the teacher asking for his input on the content he provided for them about chemical bonds. I observed the teacher teaching at a teachable moment when the students asked for support.

The teacher of the community school, who best described the connection of content evidence, was asked why he decided to have his physics class making domestic circuit for the lesson to teach electricity and magnetism. He said,

> "I wanted to see evidence that each student can take a concept that aligns with constructed evidence. I want them to show me they can construct something from a concept. Constructed circuits are evidences that the concept was understood by the student."

The low scoring school teachers were found not connecting the concepts to evidence. The study showed that the constructivist approach of learning can be enhanced by the connection of concepts with content evidence.

Table 4.5 explains the constructivists' similarity and differences from the learning facilitation point of view as compared to the theoretically prescribed frame of understanding.

Table 4.5

Comparison of Learning Approach in Sample Schools

Indicators	CS	TS	IS	Theoretically Prescribed Learning Facilitation
Similarity in learning approach	Less in conceptual understanding, and higher order thinking skills	Less in conceptual understanding, and higher order thinking skills	Less in conceptual understanding, and higher order thinking skills	Student conceptual understanding and higher order thinking skills
Dissimilarity in learning approach	More student relevance, variation of teaching methods, and integration of content and process skills and less connection of content and evidence	Less student relevance, variation of teaching methods, and integration of content and process skills and more connection of content and evidence	Less student relevance, more variation of teaching methods, and less integration of content and process skills and less connection of content and evidence	Student relevance, variation of teaching methods, integration of Content and Process Skills, and connection of content and evidence

As noted in table 4.5, the theoretically prescribed learning facilitation indicated that there should be coherent similarity in student conceptual understanding and higher order thinking but variation in student relevance, teaching methods integration of content and process skills and connection of content and evidence. All the sample schools were having less in conceptual understanding, and higher order thinking skills. However, among the sample schools, more student relevance, variation of teaching methods, and integration of content and process skills and less connection of content and evidence was in sample community school, less student relevance, variation of teaching methods, and integration of content and process skills and more connection of content and evidence in trust school but less student relevance, more variation of teaching methods, and less integration of content and process skills and less connection of content and evidence in institutional school.

Context-Specific Pedagogy Related to Constructivist Teaching

The different levels of teaching practices were apparent in connection with the context specific pedagogy related to constructivist teaching. As student misperceptions become apparent, the extent to which the teacher facilitates student efforts to resolve them by gathering evidence, participating in discussion with students was observed. In connection to the teacher student relationships, it was observed that whether the teacher demonstrated good interpersonal relations with students without any differentiation is made regarding: ethnicity, gender, multi-cultural diversity, and special education needs. As a third component, the modifications for student understanding was judged about how much the teacher modifies the lessons when necessary. Table 4.6 describes the range of the learning practices of the teachers in the three categories of the schools.

Table 4.6

Facilitating the Learning Process from a Constructivist Perspective

Variables	Not at all skilled ← (1)→	Intermediate ← (3)→	Highly Skilled ← (5)→
Resolution of Misperceptions	CS	IS	TS
Teacher Student Relationship			TS IS

	CS
Modifications for Student Understanding	CS IS TS
Average Rank	CS IS TS

CS: Community School, IS: Institutional School, TS: Trust School

As noted in table 4.6, about the Resolution of Misperceptions, when student misconceptions became apparent, the teacher from the trust school challenged students to re-examine the concepts by gathering additional evidence, by asking questions and engaging the class in discussion, and by encouraging the students to talk about the concept in their terms. The community school was poorly rated but the trust school best described for facilitating the learning process from the constructivist perspective. I observed student misperceptions in the lesson ‘Electricity and Magnetism’. During the class hour, one group of students discussed how they could construct an electric bell. The students tried to connect and construct the electric bell using electromagnet. The teacher was asked by a group of students to switch on the light in the circuit. The student told the teacher they had done. He said,

> “What is this? It is just a loop of wires, I asked you to make a circuit.”

The students smiled and said that this was the easiest thing they could come up with. The teacher walked over and asked the class to put everything down. He asked a student to turn off the lights and he then opened an audiovisual CD for the class to observe. He said to the class, “Have you ever seen the complete circuit before? Was it a loop of wire only? Are all circuits alike? Look at the screen, what you see?”

He gave the students time to talk with one another as he explained to them that their circuits must be able to glow the bulb. During an interview, students were asked to describe the teacher how he taught. One student explained, “Well, he doesn’t teach from his desk, he goes around to our tables to see how we are doing and makes sure we are all on track. He interacts with us." I asked the teacher, "How do you keep your students on task?" His reply to the questions was,

> "You see me asking students if they are confused or do not know what is going on. I take the time to acknowledge the students misconceptions. Student teacher interactions occur a lot in my class. Students discuss with me if they are confused about something. They are expected to explain why they may not understand something, to defend their answers and always be willing to discuss problems."

This provided me with evidence that the teacher confronted misperceptions through the use of evidence and discussion. Misperceptions became apparent when the group of students made a loop instead of making a complete circuit. The teacher worked as a facilitator to resolve the misperceptions by gathering evidence, and fostering discussion among students. On the other hand, as student misperceptions became apparent, the teachers from the community and the trust schools, who low scored in the rubric, did not facilitate student efforts to resolve them. Hence, it can be claimed that resolution of misperceptions is vital step in the constructivist learning practice in classroom.

In case of Teacher Student Relationships, the teachers from all the three schools demonstrated interpersonal relations with their students. The relationships I observed between the teacher and their students were very professional. The first day I observed that the room was filled with excitement, energy, cooperation, student enthusiasm, and questioning. The teachers did not seem like the teacher at the moment, but someone who was interrogating students' knowledge about the subject being discussed. Across multiple observations, I saw that the teachers made no differentiations regarding ethnicity, gender, multi-cultural diversity, and special education. The teachers often used life histories, stories, and jokes in their classrooms to get their students motivated. They had order and respect of their class. I never noticed the teacher loosing their temper, getting frustrated or loosing the respect of their students. The students appeared to act as if they were scientists in their classroom. The teacher was described by colleagues as a teacher who does not differentiate on ethnicity, gender, multicultural diversity, and special education needs. Out of 26 students interviewed, the most common adjectives used by the students interviewed were cool fifteen and funny eleven. One student described the teacher to me as, “He has fun, funny. He likes to joke a lot. He makes everybody laugh. He makes science fun.” In fact, it can be pointed out that the teachers of the sample schools demonstrated good interpersonal relations with the students. It can be claimed from the evidence that the healthy and friendly relation of teacher and students creates lively environment in the classroom for learning science.

In order to modify students' understanding, the teacher in the trust school was found continuously aware of his students’ level of understanding through social interactions, and questioning procedures. Instead of standing in front, he constantly moved among students watching closely and asking them questions. During the lessons, the teacher was continuously aware of student understanding and modified the lesson when necessary. The teacher continuously geared the difficulty of the lesson up and down through questioning in science as an inquiry. The observation protocol mentioned in Annex IX (Observation Protocol V) recorded the evidence. This provided me with evidence that the teacher from the trust school was aware of his students’ understanding of what was classified as a step. The teacher used questioning as a formative assessment strategy to identify each student’s understanding of the concept being taught. He then created additional experiences, like watching the visual in slow motion, to be sure to clear up any confusion. Once the teacher was confident the students could determine the differences between steps, he let the students work more as he reduced how many questions he asked. The teacher did not follow a lesson planning format. He allowed himself freedom to modify the lesson when necessary. The teacher was asked to describe how he planned a lesson and then modified it to meet his student's needs. He replied,

> "My lessons begin as the holistic idea. I begin with the idea and then I start to plan. Planning is a rough sketching process for me. That is where the modification process begins."

In case of the institutional school teacher, she had a general awareness of student understanding and occasionally modified the lesson when necessary. The teacher from the community school had little or no awareness in this regard and did not modify the lesson even when it was appropriate. These evidences demanded that there is constant need of modifying the lessons based on the level of understanding of students. Table 4.7 shows the constructivists' similarity and differences from the pedagogical approach as compared to the theoretically prescribed frame.

Table 4.7

Comparison of Pedagogical Approach in Sample Schools

Indicators	CS	TS	IS	Theoretically Prescribed Pedagogical Approach
Similarity in pedagogical approach	Teacher dominant	Teacher dominant	Teacher dominant	Teacher Student Relationship
Dissimilarity in pedagogical approach	Less in resolution of misperceptions and less in modification for	More in resolution of misperceptions and less in modification	Less in resolution of misperceptions and more in modification	Resolution of Misperceptions

	student understanding	for student understanding	for student understanding	and modifications for student understanding

As noted in table 4.7, the theoretically prescribed learning facilitation indicated that there should be coherent similarity in teacher student relationship but variation in resolution of misperceptions and modifications for student understanding. The entire sample schools had teacher dominancy. However, among the sample schools, less in resolution of misperceptions and in modification for student understanding was in sample community school; more in resolution of misperceptions and less in modification for student understanding in trust school but less in resolution of misperceptions and more in modification for student understanding in institutional school.

Demonstrating Content-Knowledge

The different levels of content knowledge were apparent in connection with the learning facilitation process from constructivist perspective. In case of use of exemplars, it was noticed that how frequently exemplars and metaphors (verbal, visual, and physical) were used. As a second component, concepts, generalizations, and skills were observed whether they were integrated coherently throughout the experience (lesson). In the third component, it was measured that whether content had an appropriate balance between in-depth and comprehensive coverage. The content accuracy was judged for the measure of level of content knowledge. Table 4.8 describes the range of the learning practices of the teachers in the three categories of the schools.

Table 4.8

Demonstrated Content-Knowledge from a Constructivist Perspective

Variables	Not at all skilled ← (1)→	Intermediate ← (3)→	Highly Skilled ← (5)→
Use of Exemplars		CS TS IS	
Coherent Science Experience (Lesson)		IS CS	TS
Balance between Depth and Comprehensiveness	TS	CS	IS
Accurate Content	TS	CS IS	
Average Rank		CS IS	TS

CS: Community School, IS: Institutional School, TS: Trust School

As noted in table 4.8, while concerning about the Use of Exemplars (verbal, visual, and physical), the teachers in all the three sample schools, sometimes used real life examples and metaphors to help their students understand the content being studied. All exemplars observed were accurate and relevant to the topic. Students were provided opportunities to see visual examples such as pictures and power point slides from a computer. The excerpt as mentioned in Annex IX from the ESTEEM rubric used by me, the community school demonstrated the evidence. In an interview, the teachers were asked how they felt students come to know. They explained that since they were experienced teachers, the students build those connections through manipulating things or doing projects and activities so that they now have a visual and tactile experience to put with the words. It can be claimed that use of exemplars (verbal, visual, and physical) enriches the learning capacity of students in the classroom.

In case of the Coherent Science Experience (Lesson), the teacher in the trust school focused each unit on a few major concepts. He helped students make generalizations about the concepts and use skills to reinforce understanding in a unified coherent manner. The excerpt mentioned in Annex IX from field notes taken in the science classroom of the trust school showed the evidence.

In a similar lesson delivery, the teacher from the trust school explained that his evidence that his students had learned what he wanted them to learn was two-fold. The students created a framework from previous experiences and were able to tie it together. The teachers from the community and the institutional schools did not integrate concepts, generalizations, and skills. They lacked coherency throughout the experience (lesson). From the results, it can be claimed that students making generalizations about the concepts and using skills to reinforce understanding in a unified coherent manner enhances learning.

While balancing between the depth and comprehensiveness, all contents in the teacher's classroom from the trust school demonstrated an appropriate balance. The units were not too broad for the topic. There was an appropriate balance between coverage and depth of the lesson. This provided me with evidence that the highest scoring teacher from the trust school balanced the unit by keeping his students together and on task. By working as a facilitator, the teacher provided a deep and comprehensive coverage. In the physics class all three units related to electricity, and magnetism, the circuits were focused on the major concepts of current, and resistance. By focusing on the three major concepts, the teacher could scaffold and build from one unit onto the next. Many times he referred to the previous unit while teaching the current unit providing a manageable breadth and depth. The teacher from the trust school was based on a lot of things what he did in his classroom from the moment in time so long ago. He discovered the term "teach at a teachable moment." The teacher felt that was the way one built knowledge. Similarly, the teacher from the institutional school had no appropriate balance between the depth and comprehensiveness much of the time. The lesson had too much depth for the topic and too little coverage and vice versa. On the other hand, the teacher from the community school demonstrated that the content was shallow, incomplete or some times lacking. The lesson demonstrated had neither depth nor breadth. These evidences demand that there is need of balance between depth and comprehensiveness of the lesson to be taught in constructivist teaching while learning science.

In case of content accuracy, all lessons observed in the trust school, involved accurate content. As the participant observer and a former science teacher, I was able to determine the accuracy of the content in each lesson. On the first observation of the teacher, I observed that he explained the concept of bonding from memory. The teacher checked to make sure that the delivery of the content was accurate. He also allowed his students to examine the evidence of the content in the classroom to detect any missing areas. During each observation, I examined the content and concepts for accuracy. Students constructed, developed, and presented all completed projects based on the concepts covered in the classroom. I often observed the teacher thinking out about a concept and its relation to daily experiences outside of the classroom. When asked about how important it was for a teacher to know the concept prior to teaching it, the teacher explained,

> "Once if you have the content base, it is easier to learn to become a teacher. It is easier to learn the art of teaching than it is to learn all of the information and then try to teach it. How can a teacher fully integrate something like electricity and magnetism if they do not know the entire content level of physics? How can a teacher help someone construct knowledge if they are not qualified in the area they are

> teaching? Content is the most important for me. Teaching should follow the content knowledge."

The teacher often acknowledged his errors in front of his students. I also observed the teacher explaining to his class that he was still learning, taking classes, and attending workshops so that he could provide the richest content examples to his students. The teacher was also interviewed about his science content background. He said, "I attended Tribhuvan University where I received a Masters degree in Physics." He was qualified to teach at any level except secondary level school chemistry where he lacked an organic chemistry class. In case of the community and the institutional schools, the content was usually evident and mostly accurate. It can be claimed that the content accuracy is vital for guiding learners into their track during the constructivist teaching practice in science classroom.

Table 4.9 describes the constructivists' similarity and differences from the view point of content knowledge as compared to the theoretically prescribed frame.

Table 4.9

Comparison of Content Knowledge in Sample Schools

Indicators	CS	TS	IS	Theoretically Prescribed Content Knowledge
Similarity in Content Knowledge	Less use of exemplars and more accuracy in content	Less use of exemplars and more accuracy in content	Less use of exemplars and more accuracy in content	Use of exemplars and accurate Content
Dissimilarity in Content Knowledge	Less in coherent science experience and balance between	More in coherent science experience and balance between depth and comprehensivene	Less in coherent science experience and more balance between depth and	Coherent science experience and balance between depth and comprehensiven

	depth and comprehensiveness	ss	comprehensiveness	ess

As noted in table 4.9, the theoretically prescribed content knowledge indicated that there may be coherent similarity in use of exemplars and accurate content but variation in coherent science experience and balance between depth and comprehensiveness. The entire sample schools had less use of exemplars and more accuracy in content. However, among the sample schools, less in coherent science experience and balance between depth and comprehensiveness was in sample community school; more in coherent science experience and balance between depth and comprehensiveness in trust school but less in coherent science experience and more balance between depth and comprehensiveness in institutional school.

Assessing Constructivist Teaching/ Learning Practice

Although the observation rubric was the primary tool used to examine observational data, I also examined observational data in relation to the sheltered instructional observational protocol model. As explained earlier, this model consists of the following categories: Preparation, Building Background, Comprehensible Input, Learning Strategies, Interaction, Practice/Application, Lesson Delivery, and Review Assessment. The teaching behaviors of the teacher in the trust school suggested under those categories were very similar to the behaviors identified as a level four, the best described among the three categories of sample schools under the ESTEEM category. The teaching behaviors under the category of interaction, were similar to the behaviors identified as a level four. Table 4.10 reports the results of the analysis of the Classroom Observation Rubric from the sample schools.

Table 4.10

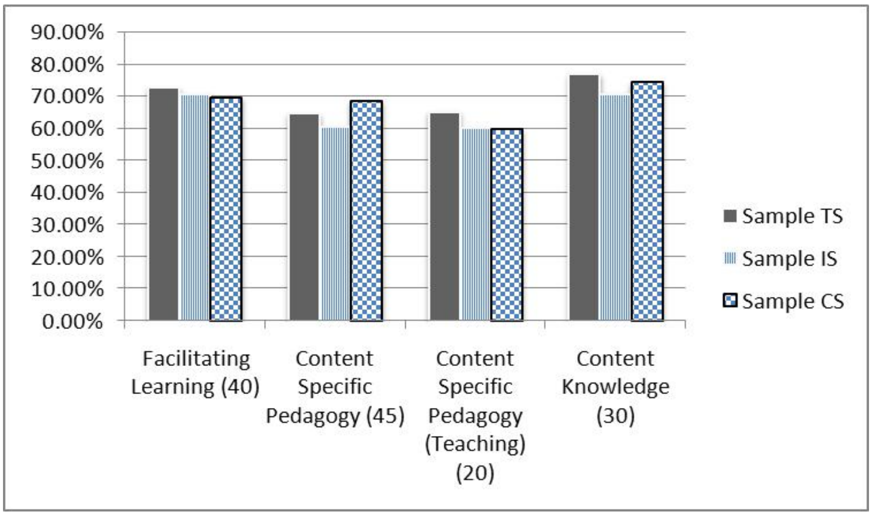
Results of the Analysis of Classroom Observation Rubric from Sample Schools

Categories	Electricity & Magnetism			Chemical Bonding			Plant Taxonomy			Atmosphere		
	TS	IS	CS	TS	IS	CS	TS	IS	CS	TS	IS	CS
Facilitating Learning (25)	17	12	14	21	18	16	19	20	17	21	19	20
Content Specific Pedagogy (Student Understanding) (30)	26	21	23	24	22	20	26	22	20	22	22	20
Context Specific Pedagogy (Teaching) (15)	15	10	11	13	10	12	11	13	9	13	12	10
Content Knowledge (20)	18	17	13	16	15	14	18	14	16	18	18	16
Total (90)	76	60	61	74	65	62	74	69	62	74	71	66
Percentage	84	67	68	82	72	69	82	77	69	82	79	73

In overall, I never saw the teacher, in the trust school, identifying for students, teaching or applying pre-determined content or language objectives in their classrooms. The overall percentage in each chapter was consistent in each sample schools. This showed that the highest score is 84% in the chapter electricity and magnetism from trust school and lowest is 67% in the same chapter from institutional school. When I examined the teachers' plan books, there were broad content goals, but not narrowly defined content objectives. The teacher and student learning process was a partnership in the trust school. The teacher sought out and used student questions and ideas to guide lessons and entire instructional units. Although the teacher with score four point in the trust school provided many opportunities for students to integrate language skills, he spent a limited amount of time on the following: Clearly defining language objectives, adapting content with a textbook, applying content and language objectives, supporting content objectives through each lesson delivery, and using language objectives to support the delivery of each lesson.

In case of teaching practices assessment, the two inventories completed by the teachers from the sample schools, were the Teaching Practices Assessment Inventory and the Assessment of Classroom Learning in Science Inventory including the categories: Facilitating the Learning Experience, Context-Specific Pedagogy related to students' understanding, Content Experiences, and Content Specific Pedagogy related to teaching. Figure 4.1 reports the results of the analysis.

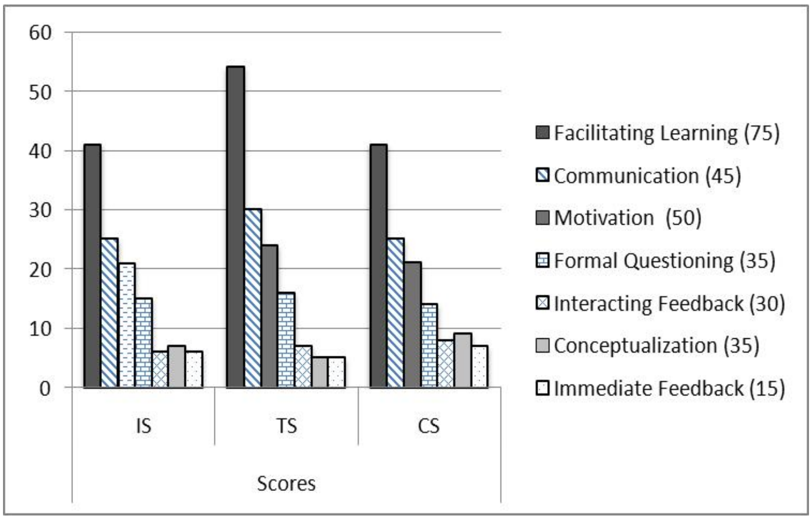
Figure 4.1: Categories of Teaching Practices Assessment Inventories from Sample Schools



These inventories were used to assess teaching behaviors. The Teaching Practices Assessment Inventory is a self-report instrument that is designed to provide a teacher with awareness of expert teaching based on the constructivist perspective of the ESTEEM instruments. The means of the totals were computed and the overall total was converted into percentage. The teachers, from the sample schools, worked on the Teaching Practices Assessment Inventory during their plan time. The levels of competence were determined for each category and then a percentage was calculated. The figure 4.1 shows that all the teachers from sample schools are competent in average with scores lying below 70%.

The Assessment of Classroom Learning in Science Inventory was taken by the teachers from the sample schools at the beginning of the observation period December, 2008. The teachers worked on the Assessment of Classroom Learning in Science Inventory during the preparation of plan at home. There were seven categories for the Assessment of Classroom Learning in Science Inventory: Assessment Communication/ Enhancing Learning, Product Evaluation/ Enhancing Motivation, Formal Questioning, Interacting Feedback, Conceptualization Activities, Grading Implementation, and Immediate Informal Feedback. The results of the rating are reported in figure 4.2.

Figure 4.2: ESTEEM Assessment of Learning Inventory in the Sample Schools



It can be seen that the teacher from the trust school is 30% away from the Expert level. He scored competent level in average and advanced beginner in formal questioning, interacting feed back and conceptualization. The teachers from the institutional and community school showed competent in first two and advanced beginner in the rest.

When asked about the Assessment of Classroom Learning in Science Inventory, the teacher in the trust school replied,

> "I have not given a specific summative test to the students in over twelve years. Concepts, criteria, and material needs to be communicated to students orally."

From these study results, it can be claimed that the highest score among the three sample schools, was the teacher from the trust school and he was competent constructivist teacher in an average for assessing teaching practice.

Table 4.11 shows the constructivists' similarity and differences in learning practices as compared to the theoretically constructed ideals in constructivism.

Table 4.11

Comparison of Learning Facilitation in Sample Schools

Learning Practice	CS	TS	IS	Theoretically Constructed Ideals in Constructivism
What worked well	Higher rating in content specific pedagogy and content knowledge	Higher rating in content specific pedagogy and content knowledge	Higher rating in content specific pedagogy and content knowledge	Content specific pedagogy (student understanding), and content knowledge
What did not work well	Less in facilitating learning and context specific pedagogy	More in facilitating learning and context specific pedagogy	More in facilitating learning and less context specific pedagogy	Facilitating learning and context specific pedagogy (Teaching)

As noted in table 4.9, the theoretically constructed ideals in constructivism indicated that there may be coherent similarity in content specific pedagogy (student understanding), and content knowledge but variation in facilitating learning and context specific pedagogy (teaching). The entire sample schools had higher rating in content specific pedagogy and content knowledge. However, among the sample schools, less in facilitating learning and context specific pedagogy was in sample community school; more in facilitating learning and context specific pedagogy in trust school but more in facilitating learning and less context specific pedagogy in institutional school.

Assessment of the Learning Outcomes

Within this theme, I present the findings on learning outcomes of the students through interactive learning tools. Learning outcomes, like learning processes, cannot be directly observed. One only becomes aware of the transfer of learning when an individual draws on the new knowledge constructed in a learning activity to try something new. Thus, learning outcomes are usually expressed in terms of knowledge, ideas, skills, or attitudes. During the study, I observed that the specific outcome of the learning design was stated as:

> "By the end of the session, learning tools and using them, the secondary level science students will be able to explain the electricity and magnetism related to the daily activities and real life situations that take place within the scope of the high school curriculum."

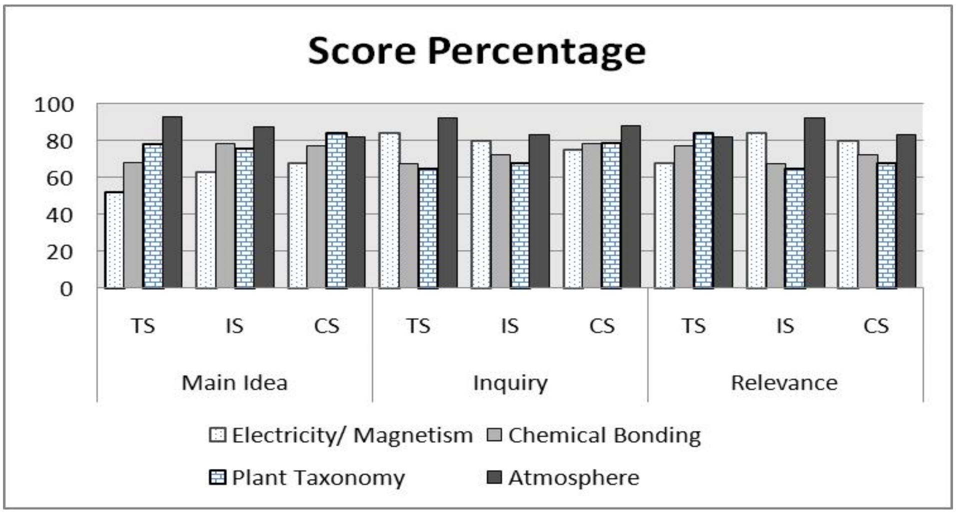
One might question how one can determine whether the secondary level science students have learned or mastered the science content using the designed learning tools. This section seeks to provide an answer to this question.

The Student Outcome Assessment Rubric and Student constructed concept maps and the Concept Mapping Rubric were inventories used to assess the secondary level students understanding of the science concepts being taught. The Student Outcome Assessment Rubric was a motivational instrument that questioned the ideas/concepts being taught, and to what degree the lesson was relevant to the students. The three categories from the Student Outcome Assessment Rubric were: Capturing the Main Idea, Student Inquiry, and Student Relevance. The students in the trust school which was highest in observation rubric among the three sample schools, were given rubric at the end of each lessons taught. The students were asked to answer three separate questions per lesson:

1. What do you think your teacher wanted you to learn today (what was the main idea)?
2. List some questions that today's lesson made you want to ask?
3. How is this topic important to you?

The roots of the rubric are in the constructivist concept of 'teaching for meaning'. These student questions were used to assess the extent to which the students understood the main idea of the lesson/ experience. The rubric was followed for all the three instrument categories for every student in each class. After analyzing all responses to the student questions, I transferred the ratings to the student outcome assessment rubric. A percentage was determined based on the total possibility for each of the three categories. The percentage scores were assigned a competency level based on the following scale: 85% -100% for Expert, 70% - 84% for Proficient, 35% - 69% for Competent, 15% - 34% for Advance Beginner, and 01% - 14% for Novice. All student responses were analyzed and scored one at a time. I scored all of the "Main Idea" questions of each student first. Once the "Main Idea" questions were scored then the "Inquiry" questions were scored. The "Relevance" questions were scored at last. All documents were classified by the lesson. The following were the extracts from the assessment rubric regarding the facilitation of the learning from the constructivist perspective.

Figure 4.3: Frequency of the Student Outcome Assessment Rubric in the Sample Schools



The results from figure 4.3 indicates that the students who completed the Student Outcome Assessment Rubric understood the main idea of the lesson, asked abstract questions, and the lesson showed relevant to the social context. The figure 4.3 shows that the learning outcome was not below proficient level and in the chapter, atmosphere, it was in expert level. Regarding the grasping of main idea, the students, on the average, scored 68.7% at the competent level for the lesson The Electricity and Magnetism, 77% or proficient level for the Chemical Bonding, 84.3% or proficient level for the Plant Taxonomy, and 93.1% or expert level for the Atmosphere. Similar results were also obtained in inquiry and relevance.

The students' concept maps were completed after each lesson and the rubric was used to score the maps. The rubric was used as a summative student assessment activity given at the end of a lesson. The concept maps were given to each student of all the three sample schools. A list of concepts were constructed and given to the students before they were asked to complete their concept maps. The five categories from the Concept Mapping Rubric are: Key and Non-Key Words, Meaningful

Connections, Meaningful Segment, and Meaningful Total Pattern. A key word list was used to score the concept maps. The Concept Mapping Rubric asked students to include words over and beyond the key word list. This scoring system was intended to encourage students to learn more concepts than those required. Students were given more points for doing this. The students in the classroom were given general instructions on how to construct a concept map. Students were not given a guideline prior to the activities being taught to them by the teacher. The percentages that were used to assign competency levels were: 85% for Expert, 70%-84% for Proficient, 35%-69% for Competent, 15%-34% for Advance Beginner and 01%-14% for Novice.

The Concept Mapping Rubrics were analyzed myself and checked by the teacher. Both used a 'Condensed Rubric for Scoring Concept Mapping' developed by Irwin (2006) after Burry-Stock as well as ESTEEM Instruments (1995) to check and scored all students' concept maps. The member check scores were consistent with the scores determined by me and the participant teachers. The results reported by the check, thus did not significantly alter my final results. I scored all of the 'Key and Non-Key Words', 'Labeled Lines' and 'Meaningful Connections'. The results of the analysis are reported in table 4.12.

Table 4.12

Average Marks of Concept Mapping Rubric of Students from Sample Schools

Topics	Key & non-key words (10)			Labeled lines (5)			Meaningful connections (10)			Meaningful segments (5)			Total Pattern (10)			Total (40)		
	TS	IS	CS	TS	IS	CS	TS	IS	CS	TS	IS	CS	TS	IS	CS	TS	IS	CS
Electricity & magnetism	6	8	7	4	3	4	7	6	7	2	3	4	8	7	6	27	27	28
Chemical Bonding	7	6	6	3	4	4	5	7	6	4	4	3	7	6	7	26	27	26
Plant	7	5	7	4	4	3	6	5	5	3	2	3	7	6	7	27	22	25

Taxonomy																	
Atmosphere	7	7	6	4	3	4	7	6	7	2	3	4	7	8	6	27	27	27

Students were able to construct their own understanding of the concepts, and connect those concepts on a map. On the final analysis and checked results of Concept Mapping Rubric, the electricity and magnetism unit, the student average was a score of 71.75% which placed the students at the proficient level. The student average on the Chemical Bonding was 72.28% which placed the students at the proficient level. The students who did a "group" concept map for the Plant Taxonomy lesson scored an average of 71.18% which placed them at the proficient level. No students scored below proficient on the lesson - Electricity and Magnetism. In this connection, Burry-Stock (1995), defined the proficient level as thinking analytically, and understanding the task.

The District Level Exam (DLE) was adopted by Nepal government in Grade eight. This assessment provided the district with information on the academic level of students in each content area. The eighth grade DLE record for science was taken at the sample schools as the schools were best described on constructivist learning practice in the classroom. The students in eighth grade took the DLE in March, 2008. It provided me a general indication of the students' understanding of science. The results of the DLE analysis are summarized on Table 4.13.

Table 4.13

Analysis of the DLE 8th Grade Science Exam 2008 Results of the Sample School

Category	Gender	Average marks in Science	Pass	Fail	Passed in			
					3rd Division	2nd Division	1st Division	Distinction
TS	Section A							

	Female	57.8%	18	1	5	10	3	-
	Male	67%	22	-	2	9	9	2
	Section B							
	Female	54.8%	17	2	4	9	4	-
	Male	65%	21	1	1	7	9	3
IS	Female	63%	16	-	2	9	5	-
	Male	72%	20	-	1	8	7	4
CS	Female	53%	30	3	3	19	5	-
	Male	61%	26	2	1	13	7	3

As a point of comparison, I examined the scores of all the eighth grade students. From the table 4.13, it can be seen that the female students scored 59% and male scored 64% in average in science subject. The similar proportion can be seen in the first, the second and the third division. Only male students appeared in distinction. This showed that males performed better in conventional summative assessment. All students in the sample classes had to take a Section Summary on each chapter taught. The student work samples were taken at the end of the lessons. All students' scores were graded by the science teacher, and member checked by me. I averaged the number of students' scores. The average score for the total student population in the science class on the section summary was 76.3%. Any score above 60% was considered to be passing. Out of 173 students, 23 students scored below 60%. 18 out of the 23 students who scored below 60% were males. There was one female who scored 58.8% below 60%. The female average on the Section Summary was 79.08% and the male average was 71.31%. The females performed 12.92% higher than the males.

Observational evidence demonstrated that students have understood the concepts of the curriculum and they were able to construct their own understanding. Interview data showed students from the sample schools believed they were learning from the teacher's approach to teaching. Student inventories demonstrated that students have understood concepts and were able to participate to build their understanding. In the sample class, males performed better than females in the DLE. In the ninth grade class and during the month of December 2008, the constructed and analyzed data by me reveals that all students were not successful. On the section summary, the female students from the sample schools outperformed the males in this assessment. The results from the Student Outcome Assessment Rubric indicated that the students have understood the concepts of each lesson well. Student Achievements provided evidence that students have understood the science concepts that was taught. The results of the student's concept maps are records showing the students understanding through a constructivist-based teaching style.

Table 4.14 describes the existing learning assessment practices as compared to the theoretically prescribed learning assessment in constructivism.

Table 4.14

Learning Assessment in Sample Schools

Learning assessment	CS	TS	IS	Theoretically Prescribed Learning Assessment in Constructivism
Learning environment	Teacher dominant	Learner friendly	Learner aligned	Learner friendly CLE
Operational	Traditional	Traditional	Traditional	Sheltered

modality	assessment mechanism	assessment mechanism	assessment mechanism	instructional protocol and concept mapping
Learning product	More capable of applying knowledge and skills in the field	More capable of applying knowledge and skills in the field	Less capable of applying knowledge and skills in the field	Concept map and capability of applying knowledge and skills in field
Learning design	More PBL and OLE	More TBIPE and PBLE	More TBIPE and PBL	TBIPE, OLE, PBL and PBLE

As noted in table 4.14, the theoretically prescribed learning assessment in constructivism indicated that there may be learner friendly CLE, and sheltered instructional protocol and concept mapping in operational modality for accessing learning. However, among the sample schools, the learning environment of sample community school was teacher dominant, learner friendly in sample trust school and learner aligned in sample institutional school; all sample schools followed traditional assessment mechanism; community and trust sample schools had more capability of applying knowledge and skills in the field in comparison to institutional school. Different learning design strategies worked in different sample schools. PBL and OLE more used in sample community school, more TBIPE and PBLE in sample trust school and more TBIPE and PBL in the sample institutional school.

Chapter Summary

This chapter presented the overall picture of the research milieu and the report on the data collected during the design and implementation of technology-based interactive learning strategies to determine whether the first research question had been answered. Data analysis through pedagogical framework established three main categories: constructivist perspectives on learning; constructivist learning design principles, and individual learner attributes. The constructivist teaching of the teacher and the students understanding of science being taught was described through four broad categories of data: observations of teaching and learning including teaching plans and teaching materials; interviews related to teaching and learning; inventories of teaching and learning; and achievements of learning. These data were analyzed to identify how constructivist-based teaching was being used in the secondary level science classroom, and how constructivist teaching helped secondary level students understand science. Findings from both the observation and field notes indicated that to some extent, the constructivist learning approach was implemented successfully. The next Chapter focuses on the learning styles, perceiving learning design, and knowledge construction from the results presented in this chapter.

CHAPTER V

LEARNING THROUGH OWN STYLES: PERCEIVING LEARNING DESIGN AND CONSTRUCTING KNOWLEDGE

Introduction

The previous chapter presented the educational setting of the research milieu and the level of constructivist learning in the selected sample schools in the course of learning science. This chapter presents a detail analysis of the perceptions and experiences of the science students of the secondary level and their teachers on the implementation of the constructivist learning design in teaching and learning. In this connection, the chapter provides an explicit account of the outcomes of the research in accordance to the criteria specified and the congruencies established between the constructivist learning principle, learning style preferences, and learning design principles. Findings of the study are organized into two major parts. The first part provides the answer to the research question, "What experiential learning style preferences are prevalent in current classroom learning environments that correspond to instructional design?". The second part of this analysis attempted to answer the research question, "In the current context, what framework of instructional design would be relevant for the classroom instructional systems of Nepal?"

Data were generated using observational evidence including field notes of classroom observations, lesson plans and other teaching resources; interviews of the teachers and participating students; survey responses from the teacher and Kolb's Learning Style Inventory (KLSI) from participating students. The analysis attempted to identify how constructivist-based teaching aligned with learning style preferences of the students, and how constructivist-based teaching was addressed in learning design. Information gathered from the observation, interviews with headteachers, teachers and students were processed and presented in the following thematic sequences.

Scaffolding the Learning Style Preferences

In order to incorporate learning style principles, learning style preferences, and the design process of interactive learning tools for the secondary level school science students in accommodating their learning styles, Kolb's Learning Style Inventory was used to access the data. The students' experiences and perceptions were analyzed in order to find instances of learning style preferences. Table 5.1 illustrates the classification based on the maximum score(s) on each learning style demonstrating the distribution of learning styles of the participatory learners according to KLSI, after the analysis.

Table 5.1

Classification of Students Based on the Score(s) on Each Learning Styles

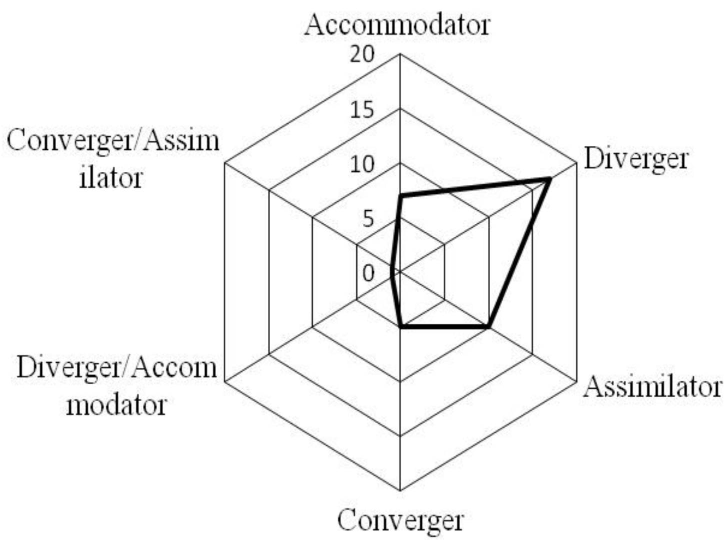
Learning styles	Frequency			Percentage		
	C S	T S	IS	C S	T S	IS
Accommodator	10	14	7	17.85	17.07	20.00
Diverger	22	34	15	39.28	41.46	40.00
Assimilator	18	20	10	32.14	24.3	26.67
Converger	6	10	3	10.71	12.1	10.00
Diverger-Accommodator	0	2	0	0.00	2.4	0.00
Converger-Assimilator	0	2	1	0.00	2.4	3.33
Total	56	82	60	100	100	100

Note: CS: Community School, TS: Trust School, IS: Institutional School

A brief description of the mapping of the students' experiences according to their preferred learning styles within the context of this study as illustrated in table 5.1 follows. Accommodators perceive experience concretely at first but move to process it through active experimentation (Group One). Divergers view situations from different perspectives and rely upon brainstorming and generation of alternative ideas (Group Two). Assimilators like to assimilate diverse facts into theoretical models, focusing upon validation of the ideas or theories themselves (Group Three). Convergers are classified as people who want to solve problems and who rely heavily upon hypothetical-deduction, focusing on specific problems (Group Four). The diverger-accommodator perceives the learning environment from the diverse points of view and uses practical models in learning (Group Five). An assimilator-converger combines theories with practice in solving problems in authentic and real-life situations (Group Six).

Figure 5.1 illustrates a cross-tabularized map of the preferred learning styles of the students to their experiences of the constructivist learning environment observed in the trust school.

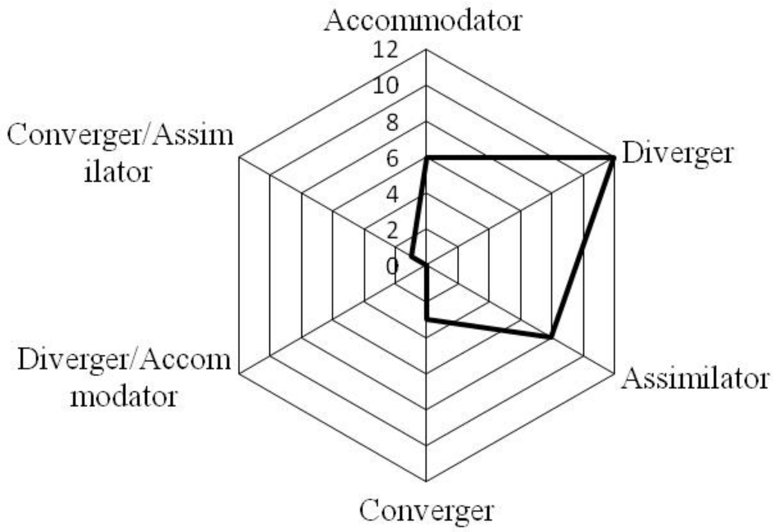
Figure 5.1: Preferred Learning Styles in Sample Trust School



In literature study, only four learning styles were reported and it was also explained that no participants in the research fell into a single learning style category; rather they displayed a dominant style together with a strong sub-dominant style. Thus, in this chapter, the sub-learning styles or sub-principles (combination of learning styles) derived from the dominant styles generated from the analysis of the interviews are used as classification scheme for data analysis as in figure 5.1.

In case of institutional sample school, figure 5.2 illustrates a cross-tabularized map of the preferred learning styles of the students to their experiences of the constructivist learning environment.

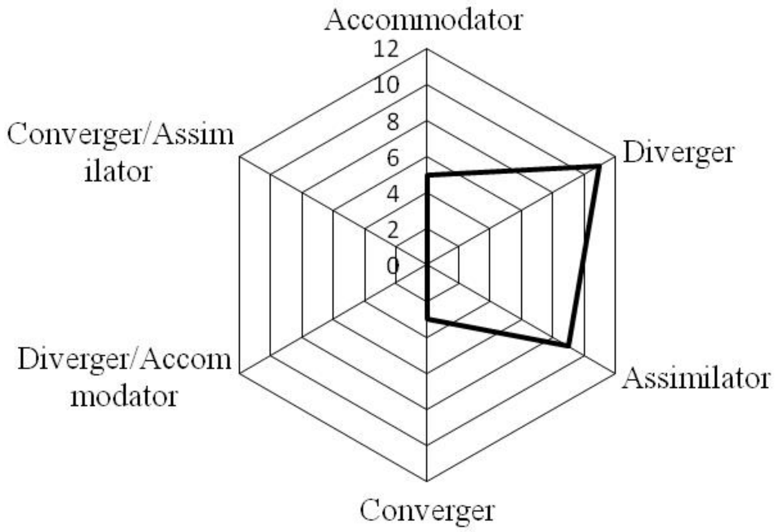
Figure 5.2: Preferred Learning Styles in Sample Institutional School



In the sample institutional school, the sub-learning style or sub-principle (combination of learning styles) derived from the dominant styles were also generated from the analysis of the data as in figure 5.2. This supported the evidence of existence of sub-learning styles in Nepalese classrooms.

Similarly, in the government funded community sample school, the Divergers, the Assimilators, the Convergers and the accommodator perceived the learning environment from the diverse points of view. Figure 5.3 illustrates a cross-tabularized map of the preferred learning styles of the students to their experiences of the constructivist learning environment.

Figure 5.3: Preferred Learning Styles in the Sample Community School



Only four learning styles were reported in the government funded sample school as in literature review. No sub-learning styles were observed on the government funded sample school.

Table 5.2 describes the contributing factors to different styles of learning as demanded by constructivism.

Table 5.2

Constructivist Contributing Factors to Learning Styles

Contributing Factors	CS	TS	IS	Theoretically Projected Contributing Factors in Constructivism
Context/ Content	Context is prevalent	Both prevalent	Content prevalent	Learning style based on the context and content
Teachers' ability	Low	High	Medium	Teacher's qualification and experience align with the learning style preferences of students
Training	Yes	Yes	No	Training about the identifying learning style may result positive impact

Physical setting	Traditional teacher centric	Student centered	Traditional teacher centric	CLE enhances the learning style preferences to balance
Learning strategies	More lecture and less practice	Variation in strategies	More lecture and less practice	Learning styles align with learning strategies

As noted in table 5.2, the theoretically demanded constructivist factors to learning styles are content, context, teachers' ability, training, physical setting and learning strategies. In sample community school, context is more prevalent, content in the sample institutional school and both in sample trust school. However, teachers' ability was low in community school, high in trust school and medium in institutional school; teachers were trained in community and trust school but untrained in institutional school; the physical setting of trust school was student centered but other two were teacher centric. Different learning strategies worked in different sample schools.

From the study, it can be claimed that there is existence of combination of two learning style preferences in the students and thus existing more than the four dimensions of the learning style preferences. Similarly, the result shows that there is unique resemblance in the polarity of learning style preferences in all the categories of sample schools best describing the diverging zone. There is no balance on the four categories of learning style preferences during science learning in the classroom.

Back and Forth of Learning Style Preferences

Accommodators or activists were characterized by active experimentation and concrete experience while considering about verbal communication and the use of the learning tool. They were people-oriented, doing well with others. They involved in handful practical skills. Considering this opinion, students were found working together when they were using the different learning tools. Supporting the evidence one student from the trust school said that if someone express verbally, she can remember partly. If she observes a program, she can remember it much better. She felt enjoyed the interactive activities. The comments made by the students also support the constructivist principle that advocates that, in the learning environment, students should be able to cooperate and collaborate in the learning process. The accommodators learned through trial-and-error problem solving in an authentic task, and in a contextualized environment. This was apparent in a student's comments on how the learning materials helped her in the working environment. Such students relied heavily on others for information rather than their own analytic ability, thus they incorporate group decision and peer group feedback that lead to success. In view of the notion of getting feedback from others, one student confirmed how she prefers to study as some people grab easier when there are discussions rather than to stay alone and read a book. This type of student, as she involved herself in a new experience, needed effective and prompt feedback during the activity, as well as feedback after the assignment completed. Along with the evidence of the effective and prompt feedback, one student explained that when she was answering the questions in the interactive tools, immediate feedback was given:

> "Before you're given the answer, you have to start answering and if you are wrong the interactive tool tells you alternatives. There are few questions that I could not manage to get the answer".

In the learning process, students should be able to receive immediate feedback, an aim that the fourth learning design principle supports. The first learning style principle that describes accommodators, states that students are actively involved in carrying out tasks and plans, as well as being involved in concrete new experiences through action. Confirming the incorporation of this principle, one student explained how she involved herself in the learning process using the learning tools:

> "I write and repeat it many times. It is easier for me to learn even though some things get strike in mind while using the learning tools".

Active involvement of students in the learning process is also shared and enhanced by constructivist principle one. From the above discussion, it is evident that learning style principle one is congruent with constructivist principles 1, 3, 5 and 7 as well as learning design principle four.

The Diverse Perspectives were also found in the learning preference. Students indicated that they preferred to study using both the textbook and the science learning tools for better understanding of the content and what is expected of them. This was explained by one of the students, who commented,

> "The text book prescribed is the point of departure. The learning tools are useful but I think we have to start with the book and then we go to the learning tools so that our expectation could be met."

This student elaborated on her reasons for using both the textbook and learning tools and said that the learning tools could motivate her.

According to Kolb (1985), people who are “divergers” combine concrete experience with reflective observation. This learning style principle states that, in the learning process, the learner is able to view concrete situations from different perspectives through observation rather than action. Learning style principle is congruent with the constructivist principle, which states that in the learning process students should be given the opportunity to view the learning content from multiple perspectives, for better understanding. Divergers or reflectors tend to use information from their senses and feelings. They observe the situation from different perspectives and rely heavily upon brainstorming, and come with alternative ideas from different points of view. One student indicated that it was pleasure and appealing to learn from the tools with interactive activities. He expressed that he prefers audio and visual playful environment that motivates and seems interesting. It also gives him satisfaction. He enjoys learning strategies and tools. He is not a big fan of textbooks and notes given by the teacher. He starts daydreaming when lecture begins. From the experiences of the students, it is evident that constructivist principle is also congruent with the learning style principle, in the sense that knowledge is constructed from different perspectives.

The greatest strength of the divergers lies in their awareness of meaning and values. This is embodied in learning design principle that stresses that the learning content or concepts must be familiar to students and must be incorporated into the design of the interface. Confirming the integration of this principle into the design of the tools, one student said: "In my opinion, both of them should be used as the book has got a broader knowledge about the content of the curriculum". Students also mentioned that they were able to understand the learning objectives of the tools. One said,

> "If you go through the overall matter, you will have a better and clearer understanding of the subject. The tools help to learn objectives as well."

According to constructivist principle, during and after the learning process, students should be able to articulate what they learn and reflect on the process for knowledge construction and understanding. This principle is congruent with the concrete experience and reflective observation of the second learning style principle, in the sense that students were able to reflect on their experience of the learning tools. The availability of basic information was also felt vital. The learning style principles assert that students are able to reason inductively, and create theoretical/conceptual models into an integrated explanation.

Students who were assimilators or theorists practiced reflective observation and abstract conceptualization. In answering a question about how they learn or prefer to study, one student indicated,

> “I must first read content before the discussion so that when we talk about the electricity then I can also give a global idea, where it starts and the processes that go up to the ends until we are ready to prepare the electric cells for their use".

People with this learning style are best at understanding a wide range of information and putting it into concise, logical form. Their approach to problems is consistently logical. This is their mental set and they rigidly reject anything that does not fit with it. The same student emphasized that, in the working environment, one needs to have knowledge of the course content in order to perform well. According to this principle, different students understand a wide range of information differently. This is illustrated by a student’s comment that through the tools one could simply follow things without difficulty:

> “When the learner has difficulty on learning with lack of previous knowledge, the learning design makes it so much easier to understand it.”

Similarly, one student, as she was answering the assessment questions, expressed the need to reflect and think before answering any question:

> "The questions demanded our insight, in-depth knowledge that we have to apply. We can’t just pick an answer. In other words, we have to be motivated, and we have to be able to know. You wouldn’t just answer.”

From the study, it can be claimed that in constructivist learning environments, assimilators need to be presented with many background facts about how and why something works, or why a problem exists. Assimilators ask questions such as "How does this relate to that?" They need to reflect on why the situation exists in that particular way, and constructivist principle explains that students reflect on perceptions from and understanding of their experiences. This constructivist principle corresponds with learning style principle.

The students valued the tools in solving practical problems. In the learning environment, the converger should be able to reason and solve practical problems. The fourth learning style is also congruent with constructivist principle, which emphasizes that students have to see the relevance of knowledge and skills to their lives, and should be able to solve authentic problems in new situations. An illustration of the incorporation of this principle was provided by one student who pointed out how the interactive learning design was relevant to her working life, and mentioned how students could make informed decisions in solving the problem at hand:

> "If there is a rare plant found and if we can access an interactive learning tool on that relating to the subject, we can always have a quick look at it and we can actually learn something even if we cannot have access to observe them in the field."

Another student mentioned how an authentic problem might be solved in an electricity and magnetism unit using the tool:

> "When they talk about harmful effects of the electricity, they first start giving you a global picture of how the electricity and magnetism in physical world look like. And when there is, an abstract thing, they point straight to where the uniqueness would be the part of the circuit that will be affected in the interactive media we just click and then we get the correct answer".

The convergers are the individuals who are best at finding practical use for ideas and theories and have the ability to solve problems and make decisions. Constructivist principle emphasizes that learners are able to interpret the learning material in any given context in the sense that before a problem can be solved, one need to interpret the context of the problem situation. In conclusion, pragmatists liked to apply new ideas immediately. They were essentially practical, who liked making practical decisions and solving problems.

Learning style principle that was derived from the literature states that, in the learning process, a learner is able to view concrete situations from different perspectives through observation rather than action (Kolb, 1999). Illustrating this principle in a student's explanation, one of the students from trust school preferred to learn using the constructivist strategies:

> "Visualization of the content is my favorite strategy. I also prioritize interactive learning tools supported by the modern technology. Observing and hearing things influence me and encourage on going through the contents. I have no concentration left on rote learning."

Learning style principle points out that students are able to reason inductively towards an integrated explanation. It is evident that diverger-accommodator perceived the learning environment from the diverse points of view and learned according to diverse theoretical models of learning in the learning environment. It can be claimed that learning style principle is aligned with each other in the sense that the learning environment should enable the learners to acquire practical knowledge and summarize it theoretically.

Access to the learning tools for solving practical problems also influenced the learning style preferences. The quotation from one student illustrated how students understand a wide range of information differently. According to learning style principle, students learn by creating theoretical models, assimilating different observations into an incorporated explanation. In this connection, she further emphasized that, in her working environment, one is required to solve practical problems:

> "We just use the materials and then we get the correct answer. When they talk about an abstract knowledge like chemical bonding, the models point straight to where the abstract would be the part of the structure that will be affected."

Based on the learning style principle, it can be concluded that the learning situation should enable students to solve practical problems in their real life context. Taking learning style principles in cycle, it is apparent that an assimilator-converger combines theories with practice in solving problems in authentic and real-life situations. It can be claimed that both learning style principles three and four inform learning style principle six which states that the learner is actively involved in new experiences as well as decision making in solving practical problems.

From the perspective of constructivists' idealized approach to learning, radical constructivists prescribed assimilation-accommodation-reflection approach of learning, social constructivists recommended diverging- assimilation continuum but cognitive constructivists claimed assimilation- accommodation approach of learning. The field findings indicate the variation in level of learning style preferences with respect to constructivist approach of learning. Table 5.3 describes the practice of learning design with respect of learning style preference in comparison to idealized approach to learning in different types of constructivism.

Table 5.3

Learning Design Practice in Comparison to Different Types of Constructivism

Constructivists' Idealized Approach to Learning		Field Findings		
		TS	IS	CS
Radical	Assimilation – accommodation-reflection	More hands on practice	Visualize from different perspective	Less hands on practice
Social (Dialectical)	***Diverging-assimilation***	Teacher as facilitator, more collaboration, combination of two styles	Instruction led structured learning	More instructivist and less collaboration
Cognitive	Assimilation-accommodation	Less theoretical orientation, more information in logical form	More theoretical orientation	No assimilator and accommodator combination

As noted in table 5.3, more hands on practice, teacher in the form of facilitator, more collaboration in activities were found with combination of two styles and less theoretical orientation as well as more information in logical form in sample trust school. They are in favor of all the three types of constructivist learning. In the sample institutional school, learning was visualized in different perspectives; instruction led structured learning and more theoretical orientation. This was less favorable for constructivist practice in comparison to the trust school. Similarly, there were fewer hands on practice, more instructivist approach and less collaboration in the sample community school. There was no combination of two learning styles as found in other two sample schools.

Learning Design and Delivery

In order to explore the learning design and delivery from the constructivist perspective, the six elements extracted from the learning design principles were constructivism, cognitive learning, component display, collaborative learning, customization and creativity. While focusing on the constructivism, it is not direct instruction rather it entails setting up learner centric environments and activities. The aim is to instill personal goals and secure active involvement in knowledge construction within real world situated learning, resulting in the type of knowledge attainment that result in applicatory skills and effective transfer. It emphasizes collaborative activities using wide varieties of learning resources. In this connection, the students indicated that they were actively involved in the learning process when they were using the designed learning strategies as learning tools. For example one student in the trust school said, “If I go through the lesson, I remember it much better. I enjoyed the lesson as it is interactive and funny ". She was supported by her classmate who experienced the tools that:

> “The activities are more eye-catching. It allows us to pay more attention, so we become more curious, we want to know more about what is happening”.

After each section of the learning content there were questions for students to answer, in order to allow them to evaluate how much they had learned. When asked for their reflection or overall impression about the assessment type of questions they encountered, one student explained,

> "The questions are making inquiry in my knowledge. How far do I? I could quickly go back and say I didn’t master this and that. Let me try and revise it. So it was sort of researching my knowledge whether I’ve learned enough."

In the learning environment, students were actively questioning the meaning and implications of what they learnt. From this study, it is evident that learning is an active and creative process that allows the individual student to discover meaning and not knowledge reception. In this regard, Chrenk (2001) also advocated that knowledge is actively built up by manipulating the objects and tools of learning.

Cognitive science views learning as a process that supports cognition, formation of internal knowledge structures within the learner and retention. Cultivating cognitive processes is seen as more important than generating products. Critical thinking skills are fostered in learners in the context of authentic problem solving or by explicit teaching of cognitive strategies alongside content knowledge. In order to indicate level of demonstrating critical Thinking in CLE, the students were asked whether the questions on the learning design were thought-provoking. One student from the trust school confirmed:

> “Yes! in-depth knowledge. We can’t just pick up an answer. You have to motivate, you have to be able to know, we wouldn’t just answer and the answer we give you have to motivate why you say that.”

The student quoted above emphasized her opinion adding: "I can say the questions demanded our insight, in-depth knowledge that we have to apply". This was also acknowledged by her classmate who said that activities were thought provoking and he should have at least thought for the answer". The students’ comments were also supported by their teachers who experienced the learning tools as methods of giving instruction. It was a thought provoking. It made them think.

These evidences proved that the design of learning strategies needs stimulation of the students to think critically so as to enable them to solve problems. Accordingly, learning content must engage students in solving complex and ill-structured problems, as well as simple problems. Also the design of learning content needs to encourage students to think critically in order to produce higher order learning that enable them to actively think towards conclusions. This means that questions in the tools should make students apply their critical thinking.

Component display theory (Merrill, 1983) examines whether the learning strategies used in a learning event can effectively achieve its learning goals. As an integral part of the system, objectives and assessment are frequently designed together. The goal of the learning design is to articulate the principles that guide future curriculum and learning strategies. In light of this, the interactive learning tools were grounded in learning design theory using the ADDIE model of learning design. The learning design principles were established and discussed in literature review and used to inform the design and development of the learning tools. Learning design for the interactive learning tools was intended to expand the knowledge base and contribute to its further validation. In answering the question: “How did you experience the content presentation or layout of the tools?” One student said:

> “I think it is more handy and time saving. On click mouse, the screen is displayed and instruction follows, you can change the templates whatever you want unlike on the book, you have to, to page through and takes time more.”

She was also supported by her classmate, who added:

> “The instructions clickable such as if you want to just go back and just check on something, you can just find them and move back, instead of going in a textbook through different pages”.

In view of the above statement, the one student indicated on answering the question about her reflection about the design and use of the tools:

> "So I think the designs were excellent and that’s also very interesting because you’re going to actually visualize, for example, the electricity

> and magnetism, you know there are diagrams and you can actually
> visualize what it's like you know ".

Another student added that the background of the tools that prompted her to pay attention that it was more eye catching. It allowed paying more attention as learners wanted to know more about what was happening. From these evidences, it can be claimed that the presentation of a learning platform must be kept consistent throughout the application (learning design principle 1). This view was also supported by Shneiderman (1998) who pointed out that one of the constituents of the notion of consistency is that consistent sequence of actions should be employed throughout the presentation. Alessi and Trollip (2001) concluded that the more the visual and spatial the content to be learned, the more integral presentation should be, and this will therefore enhance the reading ability of most students. In the design and use of the interactive learning tools of this research study, the main content with links, continued from beginning to end, throughout the presentation. Students confirmed that they were able to find their way in accessing the content of the tools. One student said that:

> "If there is any point you have left out, the computer will guide you to
> go back and restart it at the point so that you can easily understand the
> content."

Another student reaffirmed these comments concerning ease of using the tools:

> "If you want to just go back and just check on something you can just
> search on something and move back, instead of going in a textbook.
> The interlinking of the components would be useful."

The evidence proved that users of the tools must have instant access to the functions they use and the features that help to end their current session. The first constructivist principle seemed congruent with the learning design principle 9 as it emphasizes that, the learning process should enable students to actively engage with and manipulate the learning content.

Learning Design and Understanding the Learning Content were also focused while observing the delivery of the lesson. Experiencing multiple perspectives of a particular event provided the student with the raw materials necessary to develop multiple representations, which in turn provided students with various routes to develop more complex situations relevant to their experience. Answers that addressed this result came from several sources. One student pointed out, in response to the question "What could be your reflection on the text, the design and use of materials?" as:

> "The design and use of activities were very nice. I understand better when I see it either being drawn or it's in front of me or a very clear illustration in front of me. "

Responding to the question: "Have you been taught any content subject using the learning tools before?", another student said that she preferred to use both the textbook and a technology backed learning tools :

> "When you go through the learning tools at least you will get an understanding of what is expected. I could say you could first start with the book and get the points, the introduction and everything. They are in a point form but is not easily explained as in the book. So the tools designed are good but we have to start with the book."

The teacher of the participants replied to the question: How did you experience technology-based learning tools as a method of instruction or education? with the response that he thought that it was very good. It was nice to have, what was the word, different modes of teaching and so on. From the evidence, it can be claimed that students were given the opportunity that helped to engage with the content and to learn from multiple perspectives for a richer and better understanding (Principle 9). In view of the above source, the majority of the students felt that they would rather use both the tools and textbook to learn or to study for better understanding. The study was concentrated to examine if the learning process enabled students to actively engage on the learning. In this connection, as Manus (1996) said, a constructivist learning perspective addresses the theory that the students acquire knowledge that is constructed internally in their minds and in interaction with the external environment, rather than by internalizing it directly from the outside. This notion is also contained in design experiment theory: learning occurs in real-world contexts with social interaction rather than laboratory settings with social isolation (Roosevelt-Haas, 2001). It can be concluded that variety of content presentation promotes better understanding in the learning situation.

Greer (2002) also acknowledged by adding that users need instant access to the functions they use most frequently. The learning design principle became compatible with the first constructivist principle in the sense that the user of the learning materials must have instant access to the functions they use, whether links or instructions, so that the students are able to be actively engaged in the learning process and to manipulate the tools of the learning environment. In conclusion, Alessi and Trollip, (2001) also suggested that the design of learning platforms should provide the ability for the user to complete activities intended in a program, and the final message, should make it clear that the user has come to the conclusion.

In connection with the Collaboration and Empowering Learning, knowledge was found constructed within social interactions and that cultural meaning were shared and internalized. This was evident from the comments made by one student that it was necessary to share information in the learning environment: "I have to share in my life as to share is life". Collaborative learning is based on social negotiation, that is, the process of sharing reality with others. Responding to the question: Have you shared this experience of the learning materials with somebody else at work? One student said:

> "I shared some of the information with friends although I didn't show them the learning materials that you gave to us, but I shared with them."

Collaboration enables students to contribute to each other's learning. This was apparent when one student expressed that she was able to remember the learning content as a result of discussion during the learning process:

> "You will even remember when you are alone that somebody said this and that. Some people grab easier when there are discussions rather than to stay alone and read a book.".

The students' expressions listed above supported the collaborative learning that knowledge is constructed within a social context and enabled students to explore the viewpoints of others and to collaborate in the learning process.

Customized learning aims for instruction that adapts to individual learners' profile, supporting personal processes and products, and allowing learners to take initiative with regard to the methods, time, place, and content of their learning. It supports the ethos of matching learners' needs and interests within the context of learning. The design of the learning content seemed easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level. It was in line with the learning design principle which emphasizes that the presentation of the interface must be relatively simple and easy to follow for effective learning. From their experiences of studying the science content using the tools, the students agreed that it was easier to read than reading from the textbook, word by word. From the observation and interviews, it can be claimed that the presentation of the learning content needs to be simple to allow for easy access by the students. One student mentioned in her reflection on how the content of the tools was organized:

> "The content presentation was exact to the point like and also was more straightforward. When they talk about atmosphere they first start giving you a global picture of how the atmospheric system looks like and when there is a classification they point straight to where the layers of atmosphere would be."

This student further mentioned that the designs of the tools were easily formulated and were eye catching and were clearly understandable. It was evident that the design achieved this simplicity from the comments of the students. Simplicity of the tools, evolved from a pedagogically sound learning design formulated by the teacher (Milligan, 2002). This pedagogical disposition was emphasized by the comments of one student who pointed out that the technology made things simple for her teacher:

> "It is easy with the technical things because if she wants to show us something she can go back. So it is also easier to take notes with the help technical tools".

From these evidences, it can be concluded that the learning content must engage students in solving complex and ill-structured problems, as well as simple problems. The presentation of the interface must be relatively simple and easy to follow for effective learning. This is evident when the simplicity of content presentation is broken down from complex tasks into their simplest components.

Creativity supports the effective aspects of instruction, aiming for novelty within functionality, in ways that motivate learners intrinsically. Students felt need of different levels of autonomy according to ability and context. By providing opportunities for students to choose tools, content, pace, and group composition can also provide for different learning styles, language proficiency levels, and interests. Learning platform as providing choices and methods of engagement, one student stated that the tools were designed in such a way that she was in charge of the learning situation:

> "The design was excellent because of the fact that it is user-friendly. You can use it to revise quickly if you don't have time to go through a text book, if you are not very familiar with technology and not very familiar with how they actually work. You could easily move from one part of the tools to the other without forgetting completely what you were dealing with. You could just move easily between the sections of the tools".

This student's view was confirmed by one of her classmates, who believed that even if one had no technical skills, one could use the tools.

The students initiated and controlled actions, and had the sense of mastery over the tools, rather than being in the control of the technology (learning design principle 3). Similarly, the instructional material allowed students to be in control to construct knowledge and meaning, from different perspectives (Constructivist principle 2). It is thus apparent that the learning design principle 3 is congruent with both constructivist principle 1 and constructivist principle 2.

Student control is the means by which the user of an application engages with interactive content. This was evident when one student acknowledged that she was in command of the learning environment:

> "It is a very good way of providing instruction. You can go back if you're not sure, it's very user-friendly. I think it's really good".

User control has been widely researched (Sims, 1997), and the typical interpretation is that providing learners with options to make selections has positive effects on learning outcomes. In addition, the importance of student control is that it can be seen as the major factor impacting on the establishment of communication between the user and application, and there has been a wide range of approaches to student control implementation based on research findings.

The learning platform was designed in such a way that informative and appropriate feedback was provided for the progress made throughout the presentation. Evidence of the implementation of this principle was provided when students indicated that the content presentation was useful as guidance with appropriate feedback. One of the students said:

> “When you choose for the incorrect answer the technology backup will tell you that you’re wrong. You have to try again to go to the right answer. It is more guiding. The technology is better than the book."

As students were going through the tools, after each section of the learning content there were questions they answered. In response to the question: What is your reflection about the questions?, one student explained how the tools responded on performance:

> "If you are wrong it tells you so I won’t say it’s easy, because there are some few questions that I didn’t manage to get them".

This student was supported by another student who said: "It even shows you the right answers immediately as well." While students were engaging in the learning process they received effective feedback on their performance that was timely, relevant and positive. That provided an opportunity to try again. According to Burgstashler (2004), students need to be provided with an effective and prompting feedback during an activity, and feedback after the assignment is completed. In a response that supports this statement, one student related her impression about the feedback she got while answering the questions on the tools:

> "You can give the answer and get the answer right but what I enjoyed about it was, when you get answer you will know if it’s right or wrong directly and if it’s wrong you get the right answer straight".

Collaboration enabled students to contribute to each other's learning in the learning environment, engaging either with the world or interacting with learning resources or even with fellow learners. From the above experiences of the students, it is apparent that, the learning design principle which advocates for immediate feedback in the learning situation is congruent with the constructivist principle 3. This view was further supported by Greer (2002) that the learning program should provide appropriate semantic feedback that confirms the intention.

The limitation of human information processing in short-term memory required consolidation of simple and multiple displays. Users were required to remember information from one display for use on another display. Tasks needed to be arranged such that completion occurs with few actions, minimizing the chance of forgetting to perform a step. This observation was made by one of the students, who said,

> "It was actually very easy and interesting because the content of the tools were like very specific and they were summarized and were to the point instead of having reams of information and just getting lost in all that information. It was very nice and also user-friendly."

The experience of the above student was also shared by her classmate who indicated that it was best to learn through the modern technology as:

> "In one hand, the book is in a bundle form and in another hand, technology is more in a sequence form, more straightforward and eye catching. Somewhere you loose concentration as you read too much in the book. In the technological platform it is straight forward, you go from top to bottom and it is correctly tabulated in structure."

The comments of these students were reinforced by one of their classmates, who also maintained that the content presented through the technological interaction was put together in an outlined way:

> "When you read according to the technical backup, you will be able to follow the instructions as it is formulated on the display board. They

> are clearly written in tabular form beginning from starting point up to the end point."

It can be clamed that an individual human being can rehearse only limited information at a time. It also maintains that, due to human short-term memory, students must be allowed to organize content, rather than to recall it. The experience the participants gained from using the tools as learning tools exposed them to new experience in their real-life working situation. One student said that:

> "It provided us a global view. It helped us to know what is really going on with our curriculum focusing on the difficult science chapters."

The teacher of the participants shared the experiences with her students that: "They were great tools to use it for someone who never been exposed to this subject". One student emphasized the issue of experience in the working situation as important that they know about the course because if they can come here being not to work in science unit it would be difficult for them to understand".

The use of concepts and techniques that users already understand from their real world experiences allowed them to get started quickly and make progress immediately. The research indicated that the more familiar something is, the more relevant the student perceives it to be. It further confirmed that the material provided for the students must be familiar to them so as to evoke their prior knowledge (learning design principle 6). The science students agreed that they needed to be familiar themselves with the content of the course. Huang (2003) also stressed that the user of the learning material should be allowed to build on prior knowledge, especially knowledge they have gained from experience in the real world.

In the design and use of the tools, there was a conceptual map with interlinks, showing or displaying different parts of the content composition of the tools for assessment purposes. When students were being asked how they experienced the site map of the tools, one student commented:

> "The tools make things very easy as you've got idea of what is presented to you. You don't have to wonder what's going on."

Her comments were supported by the principle of learning design, which states that the information presented on the display board should be logical, followed by expectations of user and task requirements. Students' comments were in agreement with this principle, with one mentioning:

> "It is really nice. Sometimes it is hard to visualize even by picture there, to visualize say the electricity flow and then when you see the animation on the computer it just makes it so much easier to understand it."

In designing of the learning environments, the display board presentation was modified to suit users' needs and tastes. Acknowledgment of the incorporation of this principle came from a student who mentioned that the content was well written, and usually enhancing. It can be claimed that a learning program must be designed in such a way that the user can easily recognize the things used, and leads to better visualization and better understanding. In this connection, Alessi and Trollip (2001) also added that the display of learning tools should be designed for the purpose they have to serve, thus the primary task of learning design is to create a strong, consistent visual hierarchy, where important elements are emphasized and content is organized logically.

The study indicated that students were able to get help, either procedurally, for the program, or informatively within the content. Taking into account of the principle, one student acknowledged the fact that the content on the tools were designed in such a way that she was able to access it easily:

> "I could say that the content of this curriculum was clearly written and

> up to the point. I could understand each and every point as it was formulated on the display board properly."

Another student confirmed that the presentation of the content enabled one to achieve the set outcomes or objectives:

> “With the things like that where you need to move to a certain section of the tools, they were very easily accessible and you could easily move from one part of the tools to the other without having to forget completely what you was dealing with”.

Informational help means help with the content, and may be more suitable in tools for the students to access and know that is available (Alessi & Trollip, 2001). It can be claimed that the design and use of the tools should be relevant in working environment and accessible to all the learners of the class.

Based on the perspective of constructivists’ idealized approach to learning design, nine generic principles involved were: active engagement and manipulation of materials; construction of knowledge and meaning; contextualization, reflection and interpretation of learning; inclusion of multiple perspectives, authentic tasks and practice of collaborative activities in complex learning designs. The learning design principles included consistent learning platform; simplified presentation; learner controlled action; informative and appropriate feedback, more organized content than recall, familiar resources and logical user-friendly information; procedural and informational help and instant access of learning materials. Contrary to the theoretical underpinning, a field generated constructivist model (learning framework) evolved for designing learning strategies to practice constructivist science learning. Table 5.4 describes the generic constructivist learning framework regarding aligned with learning design principles and learning style preferences.

Table 5.4

Field Generated Constructivist Model (Learning Framework)

Contributing Factors	Description	Learning Strategies

Context	Creating rich and real contexts for learning to make the content concrete.	PBL and PBLE (Pair, collaboration)
Posing Problems & Questions	Posing real problems on which students work and asking open-ended questions, and encouraging students to create/ask questions to each other. Use of technology.	TBIPE, OLE (Individual, Collaboration)
Discussion	Peer or group work, interaction to reveal previous knowledge: classify, analyze, predict, and create. Content Analysis, social interaction, thinking and acting like experts.	PBL and PBLE (Collaboration)
Consolidation	Combination of peers/groups' creation through collaboration and cooperation exemplifying the multiple perspective and reality.	PBLE (Collaboration)
Concept & Contradiction	Introducing a new concept, bringing a new solution and a new perspective to the problem, scaffolding, creating clash between old and new knowledge.	OLE (Individual)
Links	In first level: creating links between prior knowledge and new knowledge, In second level: creating links beyond the context (construction of knowledge), process of enculturation, and anchored instruction.	TBIPE, OLE (Individual, Collaboration)
Utilization	Thoughtful process in which students refine	TBIPE, OLE

	concepts and ideas so that they are useful and relevant.	(Individual, Collaboration)
Reflection	Reflection on learning process, self-reflexive process.	OLE (Individual)
Evaluation	Evaluating the learning process by both teacher and students, goal-free, context dependent, process-oriented.	TBIPE, PBL, PBLE and OLE (Individual, Collaboration)

As noted in table 5.4, PBL and PBLE supported the learning strategies responsible to create and enrich real contexts for learning either in pair or in collaboration. Posing real problems where learners ask open ended questions and encourage the students to create and ask questions to each other through the use of technology were enhanced by TBIPE and OLE. Peer or group work interaction and discussion were flourished by PBL and PBLE. Combination of group works exemplifying the multiple perspective and reality were supported by PBLE. Introduction of new concept, bringing a new solution a new perspective to the problem, scaffolding, creating clash between old and new knowledge were enhanced by OLE and TBIPE. They also enriched creating links between prior knowledge as well as creating links beyond the context, enculturation and anchored instruction. Further they contributed refining concepts and ideas to make them useful and relevant. Likewise OLE supported self-reflection and all the four strategies contributed evaluating goal free, context dependent and process oriented learning.

Chapter Summary

This chapter presented the report on the data collected during the design and implementation of technology-based interactive learning tools in line with the learning style preferences to determine whether the second and the third research questions had been answered. During the data analysis, qualitative data reduction techniques were used. Data analysis through pedagogical framework established three main categories: constructivist perspectives on learning; constructivist learning design principles, and individual learner attributes.

The constructivist teaching of the teacher and the students understanding of science being taught was described through four broad categories of data: observations of teaching and learning including teaching plans and teaching materials; interviews related to teaching and learning; inventories of teaching and learning; and achievements of learning. Findings from both the observation and the field notes indicated that to a large extent, the constructivist learning approach, learning style preferences and learning design principles are in congruencies between each other. The next Chapter focuses the discussion on the analysis of findings.

CHAPTER VI

CROSS CASE ANALYSIS: THE CONGRUENCIES WITHIN LEARNING DESIGN FRAMEWORK

Introduction

This chapter provides the detailed thematic discussion about the findings of the study. Chapter five and six offered an explicit account of the outcomes of the research. This chapter begins with drawing of overview of the research findings presented in chapter four and five, and then follows the discussion. It also scaffolds the research findings based on the conclusion of the research study. The study was conceptualized around a set of three integrative themes derived from a theoretical framework, from which the design framework was generated.

To build a framework within which to come to a conclusion, findings from the discussion around the relevant research questions were illustrated. These questions addressed constructivist perspectives on learning, constructivist learning design, and learning styles according to Kolb's Learning Style Inventory. In qualitative data analysis, several categories emerged after an analysis of student and teacher data. The categories, which were yielded by the analysis intercrossed in several domains and levels, intersected directly or indirectly, and impacted on one or several other categories. By doing an across-the-table analysis of the design framework, it became apparent that several congruencies existed between the three dimensions. As the final coding scheme evolved, themes began to emerge from the data. Each theme was later matched with the research question for best fit and is summarized in Table 6.1.

Table 6.1

Themes from Participants' Beliefs

Research Questions	Themes
1. How is the constructivist learning theory and the instructional design principles incorporated in classroom instruction of Nepalese schools?	Understanding science through different tastes of learning strategies; a transformative transition from instructivist to constructivist teaching; changing role of science teachers from instructing to facilitating and then to coaching/mentoring; and CLE: a tribute to learner centeredness, learner friendliness, and collaboration
2. What experiential learning style preferences are prevalent in current classroom learning environments that correspond to learning design?	Preferring learning styles: Hindering and fostering learning
3. In the current context, what framework of learning design would be relevant in the classroom instructional systems of Nepal?	Interactive learning design: complexity versus simplicity; weaving the constructivist learning design strategies with sheltered instruction; without, within and beyond the constructivist learning design strategies

The discussions of the research are now presented in order to enable the reader to evaluate the potential appropriateness for other settings.

Understanding Science through Different Tastes of Learning Strategies

I analyzed and examined all data collected to answer the question, "Do the secondary level school students understand the science concepts being taught in the class?" Students were interviewed concerning their learning and inventories and learning achievements were collected to document their understanding. They provided additional support that the students understood the science concepts being taught.

I noticed that all the students of the group were engaged in activities during each lesson. The students were never given strict instructions, questions were answered with questions, and student ideas were always valued by the science teacher. I often interviewed students during a lesson. Students described, the teachers, the type of teachers who keeps it interesting and still can make it fun to learn about science. A majority of the students liked the hands-on working environment because they described it as the way they learn about things, by touching and feeling, to make meaning out of something. They liked the social interactions between one another and demonstrated they understood what was going on in the class. I never noticed that students were frustrated by the science concepts being taught. Students often commented through their interviews that they felt like they could 'think on their own' in science class. The students often explained to me that they were able to ask a lot of questions. Their questions were respected and they could construct their own learning from their own questions. The students told me that the teacher’s style of teaching made their learning environment a place where they got to interact with one another while learning about science.

The inventory results from the rubric indicated the students understood the concepts of each lesson. The student achievements indicated that students understood the science concepts being taught. These results are records that indicated the students understood the science concepts being taught through a constructivist-based teaching style. According to the summary of evidence supporting the students’ understanding of science, not all students learned at the same level. There were differences between the females and the males and between the two groups of students. The learning achievements (exam scores) provided different results than the inventories (specifically the concept maps).

The science content should not be simplified in any way, but the method of delivery should be adjusted to provide students with ample opportunity for participation, thereby making the concepts comprehensible. The constructivist strategies used in class were influential for transforming teaching from traditional learning to constructivist learning. The students understood the science content through different tastes of learning strategies.

CLE: A Tribute to Child Centeredness, Child friendliness, and Collaboration

The teachers worked as facilitators with their students instead of lecturing to them. They did not sit on their desk for very long. A major part of the time was spent interacting with the students in the classroom. A student described the classroom experience as,

> "Very open, a busy work station, we have to think and work in his classroom. We do not sit there during the entire class period looking at books and class notes."

The teachers helped students think, and construct their own understanding without giving them the answers. Many students described the teachers as mediators who made the learning process interesting and enjoyable. Students felt that the teachers taught so impressive that they could understand what was being taught in the classroom. Students did not feel they needed to read textbooks to understand what was being taught. The teachers explained to me that if someone is going to teach students science, the students must be given the opportunity to make their own sense of the given content. It was realized that students must have their own experiences and teachers cannot tell students how to think. Similarly, students must figure out their own experiences as they go through the learning process. The teachers were found firm believers that the students cannot construct new knowledge from reading textbooks alone. Constructivist learning environment was in fact like a tribute to child centered, child friendly and full of collaborative work environment.

The National Curriculum Framework (2007) argues that the way the students understand science is by allowing the student to construct their own meanings by linking new information and concepts to what they already know. The students come to science with world views formed by previous knowledge gained from personal and cultural experiences. Learning requires practice in new situations. In science, if the students are to learn to think critically, analyze information, make logical arguments, communicate scientific ideas, and work as part of a team, they need to apply these ideas to new and practical situations. The students need opportunities to apply the processes of science so that science comes to be understood, not as a set of facts to be memorized, but as a method for constructing important questions.

A Transition from Instructivist to Constructivist Teaching

The records of the classroom lessons were analyzed using the ESTEEM tools to determine, "What evidences are there that the current learning designs include constructivist approach?" The scores from the ESTEEM observational rubric placed the science teacher, teaching at the 'expert' level in the trust school. Observational data, interviews, inventories and achievements, all supported this assessment. They provided additional support that the teaching is at the expert level. The teachers exhibited a constructivist teaching style in average. They taught science as inquiry throughout their teaching strategies, group work, and student technology research. Teachers made minimal use of the textbook in their classrooms. Students' ideas, concepts, and understanding of ideas were encouraged in their classrooms. After analyzing the data, I concluded that the science teacher's constructivist pedagogy aligned well with the educational needs. The teacher never answered questions directly but allowed ample time for students to solve problems or construct an idea from a problem. The teachers' constructivist-based teaching style was consistent, recognized by the observer and the students as an outstanding contribution to learning science in secondary level schools. In fact, they were in transition from instructivist to constructivist teaching.

Changing Role of Science Teachers: Facilitating Rather than Instructing

According to the results of the ESTEEM instruments, the teachers were rated as 'Expert' in constructivist teaching on the Teaching Practices Assessment Inventory, and 'Proficient' in constructivist teaching on the Assessment of Classroom Learning in Science Inventory. Based on the analysis of the records using the ESTEEM rubric, the teachers were at level four in the trust school out of four units observed. The teachers considered themselves to be constructivist teachers but not at the expert level yet. The teacher would enjoy how she/ he taught and would like to maintain that with her/ his students throughout the career. It was found that the teachers take science inquiry courses throughout the year to stay current with science pedagogy, attend science training programs to enhance their knowledge in the field of science each year as participants.

In an interview with me, one of the headteachers of the sample schools stated,

> "The teacher teaches very uniquely. He wants them to find the big picture. He doesn't give them the overall concept. He gives them little pieces and asks the students to figure out what they have in common to come up with the big concept. He gives them the direction in which to

> go but doesn't give them the guidance to get there. He wants them to figure it out for themselves and in the end no matter what route they took to get there, the point is that they got there. He is the model of constructivist teacher."

The teacher was in transition from an intstructivist to a constructivist approach to teaching. The teacher might be identified as a social constructivist teacher. The teacher focused on the language and the group, and then he "radically" made students construct their own interpretations of the science concepts being taught.

Preferring Learning Styles: Hindering and Fostering Learning

The question, what experiential learning style preferences are prevalent in current classroom learning environments that correspond to learning design?, was raised in order to find out whether the students' learning style preferences were accommodated in the design and use of the learning strategies. Different learning style principles or views were identified from their experiences and analyzed. Students preferred learning with some types of learning environment better than others, depending on their individual learning style preferences. They indicated that they were actively involved in the learning process because they shared their experiences and collaborated while, and after, using the strategies as interactive learning programs. They also pointed out that the tools were contextual to their working environment and offered them hands-on experience to deal with their life activities.

Concisely, the accommodators liked the collaborative activities in the constructivist learning environment, as well as the fact that they were not restricted to a linear learning process. They could also try activities many times.

In spite of the benefits the students experienced from technology-based interactive learning designs as learning tools, some preferred to learn or study using the textbook but divergers pointed out that they preferred studying through the textbook at first and then later through interactive learning tools. Some students preferred studying through the tools and what interested and satisfied they were the illustrations, audio and visual representation of the learning content for better understanding. In a nutshell, the divergers enjoyed learning through the constructivist learning environment in conjunction with the textbook.

The assimilators had a preference towards the tools, because it gave them a global view about what was expected of them and the experience in terms of theory and the practical application of the theory. Thus, assimilators preferred to use the interactive learning tools as learning platform for it enabled them to explain and justify their reasoning and action. They liked the visuals and concept maps that were presented, and the manner in which the content was structured.

Convergers indicated that they preferred to learn through the tools because of the visual illustrations of the learning content and the interrelated structure that enabled them to access information in solving problems at the work place at a given period of time. In brief, it can be concluded that the convergers showed that the learning design was a valuable resource that could be used during solving real life problems and queries of the students.

In the sub-categories of learning styles, students had a combination of learning styles. It is evident that diverger-accommodator perceived the learning environment from the diverse points of view and learns according to diverse theoretical models of learning in the learning environment. The learning environment should enable the learners to acquire practical knowledge and summarize it theoretically. The assimilator-convergers mentioned that the tools gave the theoretical experience in solving practical problems, because of its interlinked structure contained in the concept map.

The categories of learning style preferences were also existed in combination. This made the conclusion that learning can be influenced by synergizing the different strategies applicable to particular learning style preferences. As most of the students in all categories of sample schools were found polarized in diverging category, the urgent need of revisiting on the application of learning design and delivery practice is prevalent to reform for balanced learning style preferences. The existing learning style preferences were found hindering the learning and the balanced if made in such condition may foster learning.

Interactive Learning Design: Complexity versus Simplicity

The second sub-question: how has the current learning design practices been put into operation?, reflected on the students' perceptions and experiences of the design of the strategies against a theoretical background. Different learning design principles were established and analyzed, discussion of which follows in the light of the findings.

Analysis of constructivism in the learning events display the roles that active participation, real world context, negotiation of content, peer support, positive use of errors, etc. play in personal knowledge construction. It was shown how these factors lead to higher motivation and a greater extent of work, despite the occurrence of constructivist frustration. The discussion illustrates between implementation of constructivism in well and ill-structured domains. The true constructivism was evident in the trust school. This study has shown that constructivism can be implemented in rich and varied ways. The cognitivism is the bridge between objectivism and constructivism and it has played a vital role on the learning design framework. The result of cognitive learning sets out characteristics of the various types of domains and different ways of implementing cognitive learning within them. The study has revealed that cognitive affective aspect should be addressed so as to generate positive attitudes to learning. The theory and practice gap needed to be bridged, producing learners who are equipped for the real world. Implementation of the cognitive approaches would contribute to facilitate effective learning, retention and transfer.

Creative instructional learning events contributed to motivate the learners, and helped them to enjoy learning. Although creative individuals can demonstrate their creativities under any conditions, a creative environment nurtured further creativity. Similarly, the inquiry disclosed that collaborative work has its complexities. Interpersonal issues, delays, unequal contributions, grading are some of the problems encountered. Despite the obstacles, the study has shown that collaboration has intrinsic benefits as it entails life skills and subject matter expertise, and prepared for the real world. The component display of learning, a cognitive behaviorist mix was viewed complementary with constructivism. Component display used direct instruction from the educator to the learners but the constructivism promoted self instruction and self interpretation of information by learners themselves. It can be claimed that some incorporated different kinds of knowledge through self-construction and some best taught by component display.

Learning can be customized in different ways and contemporary thinking on customization is beyond individualization of instruction. It has shown that it is affiliated with learner-centricity and matches the interest of learners by challenging them in innovative attention. Incorporating problem solving, decision making, manipulation, integration and interaction with the tools, the learners are truly customizing their learning. The design in its conceptualization was found complex addressing different aspects of learning incorporating cross discipline issues but the simplified delivery process was preferred by the learners.

Weaving the Learning Design Strategies with Sheltered Instruction

The learning design strategies were introduced and interwoven including Technology Based Interactive Practice Environment (TBIPE), Open Learning Environment (OLE), Problem Based Learning (PBL), and Collaborative Learning Environment (CLE). Besides the practice of usual classroom activities, these approaches added the constructivist learning environment where individual learning preferences were considered and learning activities were focused on the individual differences of the learners. The TBIPE focused on the modern technology in learning environment, the OLE emphasized on self learning and reflection for learners preferring the learning style – divergers. The PBL was approached to the assimilators and CLE for convergers. The combination of TBIPE and CLE influenced the accommodators or pragmatists.

There was an overlap that existed regarding the relationship between the teacher's constructivist teaching and the students' understanding of science. The teacher's constructivist teaching supported many sheltered instructional strategies such as:

1. preparation for teaching that included appropriate content, supplementary materials, and meaningful activities;
2. linking science content to student's background experience;
3. the use of multiple instructional strategies and techniques to support the learning needs of all students;

4. the use of meta-cognitive/cognitive learning strategies such as scaffolding techniques and a variety of questions to promote higher order thinking;
5. using multiple grouping configurations, allowing for wait time, and giving students opportunities to clarify key concepts in their first languages;
6. providing hands on opportunities;
7. keeping students engaged appropriate time to each ability level;
8. providing ongoing feedback to students; and
9. the frequent use of formative assessments.

These strategies forged a relationship between constructivist teaching and the students' understanding of science. Weaving the learning design strategies with sheltered instruction promoted the learning environment.

Without, Within and Beyond the Constructivist Learning Design Strategies

The learning strategies for the secondary level science students were grounded in the constructivist learning perspective. The findings confirmed that students were actively engaged in the learning process. They enjoyed the tools applied as they were interactive and found them much better ways to remember the learning contents. The navigational structure aided this engagement, as the prompt responses to the various kinds of formative assessment. Students manipulated the learning materials in several ways. The science learning strategies and the assessment questions were used to facilitate knowledge construction and meaning making. Both the technology and face-to-face formats contributed to the knowledge-/meaning-making. The findings confirmed that students collaborated, found it beneficial and were empowered to learn through the learning strategies. They shared and discussed the science content in their working environment.

Without the learning strategies, learners' and teachers found difficulty in learning process. They claimed that even informal learning foster the learning achievement. Students demonstrated critical thinking in the use of the learning materials as complex learning environment, for the questions in the tools required that they use their insight and in-depth knowledge to motivate the choice of a particular answer. They also confirmed that the questions were thought-provoking. The findings reported that the presentation of familiar contextual materials through the learning style strategies helped students to transfer new ideas and experiences to their working environment, the science units. The findings further suggested that learning the science content through the tools revealed that students could reflect on the materials and to revisit parts that had proved difficult for them. Students reported that the design of the strategies was guiding and informative, and the visual presentation of the content stimulated them to learn more.

The relevance of the learning content of the interactive tools gave students direction in solving authentic problems in their working environment. The links on the tools helped them to access relevant information. The findings verified that students acknowledged the significance of the interpretation of the learning content of the tools, with prompt feedback from assessment items. Students also reported that the interactive learning strategies enabled them to understand the learning content from multiple perspectives or compound viewpoints.

While considering the horizon of learning strategies, the participants claimed that there is enough room for the enhancement of learning process beyond the implementation of learning strategies. The strategies may limit the learner’s freedom and motivational choice in constructing knowledge.

Chapter Summary

This chapter presented the discussion about the findings of the study. The findings were thematized under the three major components: constructivist perspectives on learning; Learning Style Preferences, and constructivist learning design principles. The constructivist-based teaching strategies were being used in the secondary level science classrooms, and constructivist teaching was evidenced that helped secondary level students understand science. The learning style preferences were found polarized in converging category and the balanced scheme was felt needed. The learning styles within the sub styles were recognized in the classroom. The learning design was learner friendly and appreciated by the learners. The discussion was based on these themes.

The next Chapter focuses on the summary, conclusions, and implications from the results presented in this chapter.

CHAPTER VII

SUMMARY, NEW GROUNDED SETTINGS AND IMPLICATIONS

Introduction

As the final part of the study report, this chapter provides a synopsis of the study. Chapter four, five and six offered an explicit account of the outcomes of the research. This final chapter begins with the drawing of summary followed by conclusion of the research study. It also concludes with discussion, implications of the research findings and recommendations for further research.

Summary

I have considered that the central point of launching any reform activities in education sector demands constructivist learning design in science classrooms as a unit of reform. Instructional design for the classrooms of Nepal is the theme of the present study focusing on a constructivist approach of learning science. A single statement of the problem was devised to govern the total research study. The statement was stated as – how can a concise framework of learning be designed and developed that accommodates learning style principles, constructivist perspectives on learning, and instructional design principles?

The main aim of the study was to analyze the current thinking in cognitively based constructivist perspective of learning theory, learning style principles, learning design theory and effective practice, so as to explore existing environments, operational modalities, learning products and events of current constructivist classroom learning designs; suggest classroom learning design framework relevant to the present context of the learning systems in Nepal; and derive the implications of constructivist learning approach design, and in learning assessment. A set of three research questions was formulated to make the study more specific and to carry out the analysis and drawing conclusion in more precise manner.

4. How is the constructivist learning theory and the instructional design principles incorporated in classroom instruction of Nepalese schools?
5. What experiential learning style preferences are prevalent in current classroom learning environments that correspond to learning design?
6. In the current context, what framework of learning design would be relevant in the classroom instructional systems of Nepal?

The researcher performed in depth theoretical reviews followed by a series of literature reviews from the related research papers, articles, books and other sources. Unaddressed issues were identified and an integrated framework was designed as a theoretical framework to guide the study.

The researcher used exploratory case study design to explore the constructivist-based teaching of a secondary level school science teacher in the Nepalese school system, and to explore how constructivist teaching influenced the students and their learning of science. The data collection strategies that provided the researcher evidence of constructivist teaching were: observational evidence, interviews with the teacher, headteacher, and students, and inventories. Similarly, the data collection strategies that provided the researcher evidence of student learning were: observational evidence; interviews, inventories which included the ESTEEM rubric, and the ESTEEM Concept Mapping, and Learning Achievements. The learning style preferences were identified on the basis of KLSI and learning design was on the basis of ADDIE model.

During analysis and presentation, the data analysis framework was used. The qualitative data were transcribed and coded accordingly. The discussion was focused on congruencies of the constructivist principles with learning style preferences and learning design principles. The findings were illustrated on the basis of research questions and specific objectives. The research results were categorized under the constructivist perspectives of learning, learning style preferences and instructional design. The themes were generated during the discussion that may contribute to the Nepalese school science learners in the secondary level and their teachers who are aspiring for learning how to learn.

New Grounded Settings

An exploratory case study was employed for the purpose of this study as a way of conducting research for testing and refining educational problems, solutions and methods. The research was not, however, aimed simply at refining practice, but also at refining both theory and practice. New grounded settings were derived based on the findings and discussions of the research presented in chapter five, six and seven which include the following considerations.

A teacher as a transformative constructivist facilitator demonstrated the potentiality to perform in the classroom. Constructivist teaching supported sheltered instructional strategies including technology based interactive practice environment, open learning environment, problem based learning and collaborative learning environment. The learning style preferences of students were considered on designing learning. Learning strategies developed on the basis of learning styles preferences enhanced the students' ability to learn science more effectively.

Categories were generated from the students' experiences and their teacher's input after using the materials as learning tools and as a method of delivering instruction. The generation of the categories was guided by the constructivist learning principles. The students indicated that learning tools were interactive and engaging, which helped them to learn the content much better and with understanding. Furthermore, in their interaction with the tools, they were able to collaborate and cooperate in the learning process, helping them to remember the content as well. Both the students and their teacher accepted that the questions on the tools were thought-provoking and they had to motivate when choosing a particular answer. However, a few students indicated that they would prefer to learn or study using the textbook or those they should be taught primarily through the textbook method and thereafter using the learning tools. Despite the fact that a few preferred to receive the content through the textbook, the majority of the students' reflections on the tools as learning tools demonstrated that they were extra modes in helping them transfer their content to their authentic working environment, that is, to their lessons.

The learning materials and verbal communication with each other were applicable to help students remember and understand the learning content. The students experienced concretely that the questions in the learning tools engaged them and enabled them to engage with the content. The presentation of the learning content from diverse perspectives made it possible for students to understand the content better. The incorporation of visual content together with the text offered students the opportunity to consider the subject from different points of view. The findings authenticated that students acknowledged the value of the tools and helped them to reason in solving practical problems in the work environment. The students confirmed that they used the learning materials to enable them to solve practical problems in the workplace.

The findings suggested that learning from the diverse points of view (through concrete experience) engaged students in learning the content and enriched student's knowledge (through theoretical models). One student reflected that she used the learning materials as learning tools and later discussed its content with her classmate. Furthermore, she used the tools to assimilate extra theoretical knowledge.

Assess to the tools gave the student ideas (theoretical knowledge) for solving practical problems in science. One student pointed out that in order to solve practical problem one needs theoretical knowledge: the combination of theory and practice is indispensable in the working environment. The findings affirmed that the content presented through the tools developed student's understanding (concrete experience) in solving practical problems. This was borne out by the reflection of one student that working with electricity wires is a concrete experience and accessing the learning materials helped in solving practical problems. It was evident from the students' experiences of the technology based interactive materials (grounded in the design framework of constructivist principles, learning design principles and learning style principles) that the design and use resulted in their perceiving the materials as learning tools. Observation showed that students confidently interacted and engaged with the content of the tools. Furthermore, they said that they were motivated to learn the science content using the interactive tools. Reflecting on the field notes, students were also motivated because the modern technology is the 'in' thing, and the learning strategies allowed them to revisit parts of the content that they had had difficulty in understanding.

Most significantly, several congruencies emerged between those themes and others, that is, constructivist learning perspectives and learning style preferences respectively. Both the students and the teacher mentioned that they enjoyed the constructivist learning environment. They found the tools interesting and they made them pay attention – its visual presentation of the learning content was both eye-catching and appealing. In general, the flexible structure of the tools made it simple for the students to access the learning content, which was straightforward and to the point and helped them to understand the content of the tools. The students expressed the opinion that the design of the tools was excellent and they were in control of the learning platform, even if one was not familiar with the tools, that is, it was 'user-friendly'.

Students indicated that they enjoyed the science class as it was interactive, guiding and provided immediate feedback, unlike a book. This was evident when one answered the questions, correctly or incorrectly, in that one got an immediate response. Students were motivated to learn more as the content presentation was specific, tabulated, and summarized without leading to loss of concentration. The concept map on the tools interested the students as they were able to follow the instruction and learn the learning content. The contextualization of the learning content made students use the learning materials in their working environment. Students acknowledged that the way the tools were designed made them understand the objectives of the content of the tools and as such they did learn and understand what was expected of them.

Within the context of constructivist learning perspectives, students perceived the tools as interactive platforms that enabled them to construct and transfer knowledge from different perspectives. Students confirmed that they were empowered to transfer knowledge to different environment. The relevance and diversified interpretation of the learning content of the tools helped students to solve problems (constructivist learning perspectives). The user-friendliness of the design of the interactive learning tools made it easier for the students in the sample schools to access the relevant learning content than from a book. The students confirmed that the organization of the learning materials, made it easier to understand the content. Furthermore, they indicated that the design of the tools, which provided them with immediate feedback and a consistent interface, enhanced their experience and understanding in working environments (learning design). They revealed that the design of the learning tools accommodated the way they preferred to study. The presentation of the content in the tool created a verbal communication platform among the students, enabling them to retain the illustrated information better. Accessibility of the tools assisted the students to combine theory with the practical experience of solving the problems related to the real life situations (learning style preferences).

From the above conclusion, the three integrated design principles (constructivist learning perspectives, constructivist learning design and learning styles) determined the extent to which the implementation of the interactive learning tools were successful. It was found that, to a large extent, the implementations of the constructivist strategies were in line with the design framework derived from the principles generated in the theoretical framework.

The field notes recorded from the participants' interpretation of the learning situation demonstrated that students wished that all their courses were on the learning platform for it was a motivating and interesting way of studying. However, not all the students preferred learning tools as a method of studying: some preferred to use the tools rather than textbooks, and some preferring a combination of the textbook and the tools. Students were happy and motivated after the implementation of the tools.

Contributions of the Research

The study has made a contribution to the field of educational technology. The study confirmed pointing out that the articulation between learning styles and constructivist learning principles are in line with the design of constructivist learning strategies. A set of design principles was derived in the course of the research which may be used as a framework for the design of constructivist learning environments in similar Nepalese contexts. The design framework was generated by the mixed method research methodology. The second contribution of the study is in the field of science education. The design and use of interactive learning materials and the assessment of the value of the materials in similar contexts was, indeed, meaningful.

The main aim of the study was to design and develop learning strategies, based on a constructivist perspective that accommodates the learning styles of secondary level school science students. Furthermore, the research was denoted to construct a conceptual framework for the design and use of the learning strategies by identifying congruencies between the components of constructivist perspectives on learning, the individual learning styles of the learners, and learning design principles. This aim was achieved by generating a framework for the design and use of interactive learning materials about science learning. This framework can be used as a baseline for similar purpose in the future. The design framework addressed issues of pedagogy, instructional design, and the accommodation of students' learning styles within the constructivist perspective. No such design framework clustering the dimensions of constructivist perspectives, learning design and learning styles are found in the relevant literature.

After the analysis of the three dimensions, it became evident that several congruencies exist between them as illustrated in theoretical framework. In spite of that, a relationship was apparent between the design principles that were derived from constructivist learning perspective and those from learning style theories. Further, the learning design principles were congruent with both the constructivist and learning style principles. Theoretical principles were derived to guide the practice and to inform future designs. The case study research method is regarded as an educational intervention and was followed to conduct the research work with respect to testing and refining an educational design. This method provided a valuable window to see through what happens when technological and curricular innovations are brought into classroom settings. This research, therefore, made a practical, scientific and pedagogical contribution and ensured a more productive inquiry.

From the students' perceptions and experiences it can be inferred that the research was implemented successfully. Those particular aspects of the design framework that were engineered into science learning tools were experienced positively by the students. In addition to crafting a design framework that can be used in similar contexts, the study has empowered science students to engage confidently with educational technology.

Implications of the Study Results

The focus of the study was on constructivist teaching and its enabling influence in students' learning of science effectively. The researcher came to this study with a background in secondary level science teaching, a belief in the science learning design enhancement and an understanding for the need of educational enhancement in society today. The concise integrated model is helpful to sequence learning experiences to construct their understanding of concepts to be learned.

Philosophical Implications

The massive construction of knowledge in the world has created a problem that we can no longer attempt to anticipate future information requirements. If students are to keep pace with the rapid increase of knowledge, we cannot continue to organize curriculum in discrete disciplines as we have known them, no longer exist.

They are being replaced by human inquiry that draws upon generalized trans-disciplinary bodies of knowledge and relationships.

In order to claim that one is a constructivist there are certain philosophical implications to the way one teaches. These philosophical implications do indeed lead to best practices in the constructivist teacher's classroom. Some of the practices that were common amongst all of the models were a greater understanding of developmental psychology and learning models, group learning using cooperative learning strategies, active cognitive involvement (hands-on - heads-on), personal input from students regarding relevant information, student centered - not subject centered classroom environments, integration of subject matter to convey connections to the experiential world, interaction, discussion and reflection, and flexibility of teacher in both curriculum and pedagogical strategies. What is interesting is the lack of behavioral objectives or specific content related outcomes. It seems that if we are to address the problem of being able to use knowledge, we must teach our students how to access and use knowledge that is already present, to solve problem, and to understand inquiry skills so that new knowledge can be obtained. These skills can only be taught through the content and process of doing science.

Implications for Teaching: A Room for Multi-grade/ Multilingual Practice

Constructivism has important implications for teaching. People sometimes confuse learning theory and instructional theory believing that teachers should avoid setting clear goals, guiding instruction, or correcting student misconceptions. Constructivism supports none of these practices. Instruction based on constructivism emphasizes high-quality examples and representations of content, high levels of student interaction, and content connected to the real world. Teachers who ground their instruction in constructivism realize that lecturing and explaining often fail to promote deep understanding in learners.

If students must apply their current understandings in new situations in order to build new knowledge, teachers must engage students in learning, bringing students' current understandings to the forefront. Teachers can ensure that learning experiences incorporate problems that are important to students, not those that are primarily important to teachers and the educational system. Teachers can also encourage group interaction, where the interplay among participants helps individual students become explicit about their own understanding by comparing it to that of their peers. If new knowledge is actively built, then time is needed to build it. Ample time facilitates student reflection about new experiences, how those experiences line up against current understandings, and how a different understanding might provide students with an improved (not ‘correct’) view of the world.

If learning is a constructive process, and instruction must be designed to provide opportunities for such construction, then what professional development practices can bring teachers to teach in student-centered ways? Construction in learning is not just the domain of children but of all learners. Constructivist professional development gives teachers time to make explicit their understandings of learning, of teaching, and of professional development. Furthermore, such professional development provides opportunities for teachers to test their understandings and build new ones. Training that affects student-centered teaching cannot come in one-day workshops. Systematic, long-term development that allows practice - and reflection on that practice - is required.

There is a room for multi-grade and multilingual teaching in constructivist teaching as learning is individualized and learning takes place in collaboration.

Constructivism represents one of the big ideas in education. Its implications for how teachers teach and learn to teach are enormous. If our efforts in reforming education for all students are to succeed, then we must focus on students. To date, a focus on student-centered learning may well be the most important contribution of constructivism.

Implications to the Science Teaching

Another implication of the findings is to include more constructivist strategies to give teachers an intense opportunity to examine science content in the classroom. The data indicated that the students demonstrated a higher level of understanding of the science concepts. Giving the students more scientific opportunities in the classroom can enhance conceptual understanding of the concepts being applied. Enhanced science investigations can actively involve students in carrying out the processes of science by moving from observing and measuring concrete objects to classifying, hypothesizing, and interpreting results. The expectations were higher in the class. Influence of constructivist practice is extremely needed for the science learning. The constructivist practice is therefore helpful to allocate resource, selection of learning strategies and manipulation of learning materials on the demand of learners' individualized preferences.

Science teaching cannot be viewed as the transmission of knowledge from known to not-known; constructivist teachers do not take the role of the ‘sage on the stage’. Rather, science teachers act as ‘guides on the side’ who provide students with opportunities to test the adequacy of their current understandings. If learning is based on prior knowledge, then science teachers must note that knowledge provides learning environments that exploit inconsistencies between learners' current understandings and the new experiences before them. This challenges science teachers that they cannot assume that all children understand something in the same way. Further, children may need different experiences to advance to different levels of understanding.

Implications for the Classroom Management

The classroom management involves communication, motivation, learning techniques and methods, physical environment and discipline and evaluation. Student centered activities, student engagement, teacher asking questions rather than giving directions, and hearing students' voices are implied to constructivist classroom communications. There is no punishment, no prize but there is intrinsic motivation in constructivist classroom. Students are motivated by the learning itself. Teacher and students accept classroom as their own class. The techniques and methods involve encouragement of students' direct involvement through discussion, group-work, students' presentation, debates, simulations, brainstorming and individual study. There should be student autonomy. Teacher accepts individual differences, and encourages for higher level thinking. Students engage in experience. The physical environment in a constructivist classroom considers the walls with students' works. Every student can see each other in class and desks should be movable.

Students should be made responsible individual to be autonomous learner. Evaluation should be for learning. Learned information should be evaluated not the memorized ones. Learning should continue on evaluation. The process of learning should be evaluated not the outcomes. Performance, problem based learning, group works and practical matters are used for evaluation.

Implication to the Assessment Practices

Another implication of this study is to apply different assessment practices. From the findings, it can be seen that not all the students were successful in science subject in grade eight. Even though the teacher was identified as transformative cum constructivist teaching, one female student scored in the 'Unsatisfactory' range on the District Level Exam (DLE). Males performed better than females on the school exams. On the Section Summary of the science chapters taught, the female average on concept mapping was more than the male average. Even though it seemed that the males out performed the females based on the existing learning evaluations, females outperformed males based on the rubrics. Additional research is needed to further explore this relationship between gender, assessment strategies, constructivist teaching, and the science learning of the students.

Implications for Teachers/Facilitators

This approach of learning is a guideline for the facilitator and teachers to adapt in classroom individualization of learning. Students' levels of participation in the learning process are linked to their teachers' levels of participation in their own learning processes. If teachers are to make the necessary changes in moving towards constructivist classrooms, they need to be supported in their own learning. It is roadmap to achieve divergence goal of learning. This integration of constructivist learning principles, learning design theories and learning style preferences help learners learning by social interaction. The best practices of learning achievement evaluation are possible through constructivist approach and helpful for student understanding. Minor changes in teachers' practices, as described above, can effectively convey to students that what they think and say.

Implications for the Students/ Learners

Students taking responsibility of learning, led by own ideas, informed by ideas of others, participate in constructivist learning environment, listen to others, prepares individual constructed act in a milieu of social interaction/ negotiation.

Constructivism allows students to interact with real-life experiences and construct mental structures that provide an understanding of their surroundings. In order for students to develop these mental structures, they must refine the skills needed to solve the problems they encounter. The typical teaching model in most classrooms is direct instruction. The constructivist classroom should be much different. The students, rather than the teacher, are responsible for organizing information, exploring learning environments, conducting learning activities and monitoring their own learning.

Students are important and their questions are highly valued. Creating a learner-centered classroom allow the students to construct their own knowledge and develop their own understanding. As such constructivism can be implemented in classrooms of all ages and levels of ability, and constructivist teaching is effective teaching.

Implications for Teacher Educators

The teacher preparation can play the important role in developing a constructivist teacher. The teacher educators have to consider the integration of constructivist learning principles, learning design and learning style preferences so as to increase the role of teachers and prepare the module for the teacher training.

Programs influenced by the developmental tradition attempt to teach students how to teach in a constructivist, generally in Piagetian, manner. Piagetian developmental theory and research are necessary to use them as core knowledge for preparing school teachers. Developmental-constructivist principles of knowledge acquisition are particularly well-suited for this purpose because they have implications for what and how children are taught, how progress toward expertise in teaching is conceptualized, and how teachers are educated. Programs influenced by social reconstructionist tradition attempt to help teacher education students deconstruct their own prior knowledge and attitudes, comprehend how these understandings evolved, explore the effects they have on actions and behavior, and consider alternate conceptions and premises that are more serviceable in teaching. Critical analysis and structured reflection on formal course knowledge and everyday practical experience are necessary to incorporate.

Implications for Curriculum Designers

When working with children, it has been suggested that competency-based models of curriculum development often produce written guidelines that may not line up with where students actually are. Teacher reflection and mediation are considered to be important factors in bringing about this matching. The teacher functions as a developer and deliverer of curriculum. From a constructivist perspective learners should be heavily involved (with teacher assistance) in determining objectives, learning opportunities, and evaluation procedures.

A number of different flexible strategies must be combined if curriculum development is to be truly constructivist in its perspective. There is no single 'right way' for constructivist curriculum development. Matrix technique is offered as one possible way of organizing the ideas, knowledge, discussion and inquiry of students in science classrooms, with the intention of promoting the individual and social construction of viable knowledge. The introduction of constructivist reforms ideally occurs through meaningful negotiation of both the learning environment and the ideas about knowing and learning with students.

Implications for Learning Designers

Instructional designers design and develop learning experiences. One of the crucial things instructional designers can (and should!) do is make sure that students have opportunities to practice actively what they are learning. What the instructional designer adds to the process is the experiences of learning and practicing. Instructional designers know how people learn and have ideas on how to help them learn better. If we are looking for engaging learning activities or ways to make practice closer to real life skills, we need instructional designers. Instructional designers are expected to be familiar with the epistemological underpinnings of several theories and their consequences on the process of instruction. Each of six elements in the learning design together represents a systematic way of organizing for constructivist learning. These elements include:

1. Situation (arrangement for the students to explain),
2. Groupings (of students and materials),
3. Bridge (between what students know and what they might learn),
4. Questions (teachers will ask or anticipate students will ask),
5. Exhibit (of student explanations for others to understand), and
6. Reflections (by students on their process of explanation).

This research discussed the basic principles underlying constructivism, particularly active, collaborative and authentic learning. Application of these principles on the process - analysis, development, evaluation - of instructional design poses certain challenges like pre-specification of knowledge, authentic evaluation and learner control. Instructional designers must attempt to translate constructivism into instructional design through a more pragmatic approach that focuses on the principles of moderate - rather than extreme - constructivism and makes use of emergent technology tools. This shift could facilitate the development of more situated, experiential, meaningful and cost-effective learning environments.

Implication for School Leadership

The school headteachers must understand the commitment level necessary for the creation of constructivist learning environment and show willingness for its practice.

The teachers interviewed in the study recognized the demands and tensions of the leadership role. Their comments ranged from critical insights of leadership in action, to perceptions of leadership as ‘learned behavior’. There is a good deal of evidence from studies elsewhere that is compatible with this view of ‘learned’ leadership capacity. Leaders are stimulators (who get things started). They are story-tellers (to encourage dialogue and add understanding). They are net-workers and problem-solvers too. They care deeply about teachers, about students and about education. In such settings leadership provides a context for professional learning focusing on helping teachers to confront, making sense of and interpreting the emerging circumstances of the school.

The effective leaders tend to be viewed as facilitators who delegate and empower others. Such leaders provide a clear vision for the schools they lead based upon certain fundamental values and beliefs. It would also appear that where leadership is both learned and shared, there is more possibility of organizational development and change. Within the accounts of teachers in this study it was clear that they were both aware of and involved in the process of leadership. They were both contributors to and recipients of effective leadership practice.

Constructivist leadership involves the active making of meaning, the formulation of one’s own set of purposes and guiding principles. It means engendering a way of life, not merely living according to the blueprint of others. It involves leading communities of enquiry in which the agenda is owned by that community and is constantly evolving, developing and being constructed through questioning and dialogue. “Making, not copying” and “Learning together” indicate the ability to respond to change.

Implications for Policy Makers

Policy makers must realize the impact of policy decisions on successful implementation of flexible contextualized curriculum, constructivist learning environment and formative assessment system of learning. Unlike institutionalists, constructivists acknowledge the fluidity of relationships. Policy-making participants develop and sustain with other network actors outside the boundary provided by the organization. The research has indicated that a significant proportion of policy-making participants have changed their beliefs. Learning, this analysis has suggested, is most frequent among actors who belong to wide scope networks and who have a trusting attitude.

Recommendations for Further Research

A research can contribute to a theoretical understanding of learning and lead to a refinement of the educational materials and the design. It would be valuable to be able to make a claim about acceptance and efficiency of the findings of the research if further researches produce evidence of the value of the design framework in similar situations. There needs to be more research conducted in the field of constructivist-based teaching and the students’ understanding of science in Nepal.

This research was an exploratory study to examine constructivist science classroom of the secondary level schools and how constructivist teaching helps the students understand science. This was an exploration to identify the relationships between constructivist teaching and student understanding. This exploration has indicated that constructivism is an appropriate strategy to help students understand science. Further research is needed to determine if these findings are transferable to a larger audience, or if they are unique to them. It is possible that other teaching variables might be equally influential in helping the students understand science. Further research should involve a large number of teachers and students, additional grade levels, additional subjects, and additional environments. This additional research might further help to answer the question, “how can a concise framework of learning be designed and developed that accommodates learning style principles, constructivist perspectives on learning, and individual learner attributes?” in different contexts.

Further research might also explore the constructivist-based teaching of teachers who have endorsements in both secondary level school sciences in English language and in other languages. That might lead to new discoveries explaining how the students understand science at the secondary level. This additional research may increase our understandings of the significant relationships between science education strategies, incorporation of learning style preferences, and constructivist teaching approaches.

In addition, further research is needed to more deeply understand the gender perspective on the relationship between constructivist-based teaching and assessment strategies. This research may help explain why the males outperformed the females based on Learning Achievements (traditional tests) but not based on the Student Inventories (concept maps). In a time of increased accountability and testing, we need to be sure about our testing strategies as free of bias in language and culture. If certain assessment tools are more appropriate for assessing learning for males while others are more appropriate for assessing females, it is crucial to use a variety of assessment tools with both genders and not make important instructional decisions based on one assessment. It is also important to look at differences in assessment results for science students learning science in English language compared to native languages.

The ESTEEM inventories documented higher levels of understanding for the students compared to the learning achievements which were more traditional assessments. Sheltered instructional strategies and constructivist practices both highlight the importance of multiple culturally and linguistically appropriate assessments for the students. Future research might explore which assessment strategies are most appropriate for culturally and linguistically diverse students as well as both males and females.

The Final Words

This research study was underpinned by three philosophical epistemologies in contemporary social research, namely: positivism, interpretivism and critical framework. These underlying philosophical assumptions embraced the research methodology which explicitly exploits the design process as an opportunity to advance the researchers' understanding how secondary level science students experienced the constructivist learning environment. Furthermore, the research supported the design framework which focuses on the collection of coherent design guidelines.

The research questions that were defined start with "How is..." and "What is …" or "What are .... ". This illustrates that the researcher was interested not only in knowing whether the learning design affects the learning of science, but specifically in understanding how it does this. This character of the research questions links to the general objectives of research design. The positivistic perspective is concerned in uncovering the truth about specific correlations and associations among variables and presenting it by empirical means. Through the positivistic lens in this study, the researcher managed to capture how the secondary level school science students experienced the learning tools as learning materials, in a real-life context.

The interpretive discourse, on the other hand, facilitated interpretation of how the students perceived the design of the tools. At the same time, these philosophical positions opened the door for critical reflection on how the students experienced the learning content through the materials and what can be learned from their experiences.

The study has provided a design framework that was generated from the three theoretical lenses, or pillars: the constructivist learning perspective, learning design, and learning style attributes. This framework was used for the design of the learning strategies for the constructivist classroom. The positivist position is that a statement is proved true if it agrees with an independently existing reality, and is false if it does not. The students' positive experiences of the use of the materials as learning tools, then, confirmed that the design framework agreed with the independent existing reality of their experiences. The interpretivist concept interprets and evaluates the learning outcomes. The students' interpretation and positive experiences of the tools based on the design framework offer evidence that they have understood the learning outcomes of the content of the design. Simultaneously, the paradigm of critical theory encourages evaluators and instructional designers to question the underlying design framework for the effectiveness of the instructional products. From the above philosophical positions it can be seen that the framework generated by this study for the design of constructivist learning environment, may be utilized for prospective design.

Chapter Summary

This chapter provided about the over view of the research work as a summary, the conclusion of the research findings, contribution of the research and implications of this study in different sectors of educational fields. The purpose of this study was to explore constructivist science classroom of the secondary level school and examine how constructivist-based teaching influences the students and their learning of science. This exploratory study was constructed through multiple lenses of science teachers, headteacher, students, and the researcher. This study revealed the science teacher, as a teacher who has a passion teaching and someone who helps secondary level school students understand science through constructivist teaching strategies.

The job of educators is to provide multiple opportunities for the enhancement of student conceptual understanding of the concepts being taught in the classroom today. As teachers we must examine processes, strategies, in-service opportunities, curriculum changes and educational advancements to enhance our own values and growth so that we understand the variables needed for opportunities so that "all" have the ability to grow and learn in our societies today. It was revealed through the four broad categories of data collected by the researcher, that the teacher's constructivist teaching provided the students an opportunity to understand the science concepts that were being taught in classrooms of secondary level school.

These results provide insights and guidance, for improving science instruction at current contexts as well as suggestions for future research. As educators, it is our goal to prepare students to become educated consumers of scientific information and ensure that our nation's children reach their potential.

The constructivist view is grounded in the notion of subjective reality characterized by individual's thoughts, experiences, perceptions and abilities. Individuals construct their own reality from their observations, reflections, and logical thought. Constructivism is an epistemology, a theory of knowledge used to explain how we know and what we know. In social constructivism the focal points are the language and the group. In psychological (cognitive) constructivism the focal point is cognition and in radical constructivism, the focus is on the individual. Social constructivism emphasizes the importance of culture and language based social interactions and formation of knowledge at a group level. Psychological constructivism emphasizes the importance of cognition in understanding how an individual builds and assess knowledge. Radical constructivism demands the individual focus in her/ his attention on multiple perspectives of learning environment.

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Annexes

EXPERT SCIENCE TEACHING EDUCATIONAL EVALUATION MODEL (ESTEEM)

(BURRY-STOCK, 1995)

SCIENCE CLASSROOM OBSERVATION RUBRIC (Teacher)

INTERVIEW GUIDING QUESTIONS

For Head Teacher:

1. Tell me about your science teacher and his teaching.
2. Tell me about your students and their learning.
3. Do you think they understand the science concepts being taught? What is your evidence?
4. Please tell me about your experience of being headteacher in this school.
5. What problems exist in the science classroom that is hindering secondary level school students learning science?
6. What do you suggest to improve for science learning in secondary level schools?
7. What best practices are there in your school that is enhancing learning science?

For Secondary Level School Students:

1. Tell me about your classroom.
2. What is your favorite subject? Why?
3. Tell me about science.
4. Tell me about your teacher.
5. How does he/she teach?
6. Tell me about what you are learning right now.
7. What did you know about this concept before this class?
8. What have you learned from this class?

For Teachers:

1. Tell me about your students.
2. Tell me about your teaching.
3. Tell me about your lesson or unit you are teaching now. Why are you teaching this concept?
4. Is it important for your students to learn? In what ways? How does it relate to other concepts your students have studied?
5. Do you think all of your students understand this concept? What is your evidence?

For Biography of School Science Teacher:

1. Describe the community and schools where you grew up.
2. What was science like for you when you were in secondary level school?
3. Describe how your science teachers taught you in secondary level school.
4. Describe your experiences with science in secondary level school.
5. Describe your experiences with science in college life.

Opinion about Science:

1. What does science mean to you?
2. How do you think students should learn science in English medium?
3. What are effective teaching strategies to teach science?
4. How do you define success in a secondary level school science classroom?
5. How would you describe science epistemologies in secondary level school science classrooms?

Opinion about Teaching:

1. Why did you choose to teach science at the secondary level school?
2. Tell me about constructivist-based teaching.
3. How do you think teachers help students come to know?

4. In which ways do you feel you are reaching your students in the classroom using English medium?
5. How do your students react to science curriculum in English medium classroom?
6. How do your students react to difficult or challenging curriculum in English medium class?
7. Describe your own philosophy about how your students learn science in English medium.
8. Tell me about your most effective science lessons.

About Teaching Pre-Unit:

1. Tell me what you plan to teach?
2. What major skills or concepts are you trying to teach?
3. What will be your evidence that students have learned what you want them to learn?

About Teaching Post-Unit:

1. Tell me about what you taught?
2. What major skills or concepts did you use to teach the unit?
3. What will be your evidence that students have learned what you taught them?

OBSERVATION PROTOCOL

Length of Activity:

Descriptive Notes:	Reflective Notes:
General Notes:	
Sketch of Classroom	

EXPERT SCIENCE TEACHING EDUCATIONAL EVALUATION MODEL
(ESTEEM, BURRY-STOCK, 1995)
SCIENCE CLASSROOM OBSERVATION RUBRIC (Teacher)

Instructions:

The Science Classroom Observation Rubric is used to assess expert science teaching from a constructivist perspective. A rubric is an analytical scoring guide. In order to administer the rubric, documentation is needed. Documentation may be in the form of a written record (script of all classroom activities, presentations, interactions, etc.). This is true for self, peer, or external evaluations.

Classroom behaviors from the record are to be compared with the descriptions in the rubric (scoring guide). If the classroom behavior is best described by the "5" level description, then the rating should be a "5." If the classroom behavior is best described by a "3" level description, then the rating should be a "3." However, if the classroom behavior would be best described somewhere between a "5" and a "3," then a "4" rating should be used. A "2" rating would fall between a "3" and a "1." Teaching practices are described at a "5," "3," and "1" level. Ratings of "4" and "2" should be used when the behavior would be best described between "5" and "3" and "3" and "1" respectively.

ESTEEM PRE-OBSERVATION FORM

An observation form should be completed before a classroom observation is done.

Teacher______________________ Date___________________

Observer (if there is one)

School______________________ Grade_______________________

Class Period or time of Lesson:

Topic of Lesson:

Length of the Lesson or Module:

Placement of lesson within the Unit of Study Purpose of the lesson:

Intended Outcome:

Materials and/or text used (Copies should be given to the observer ahead of the classroom observation.)

Other Comments:

ESTEEM (BURRY-STOCK, 1995)

SCIENCE CLASSROOM OBSERVATION RUBRIC

(Teaching Practices)

Category I: Facilitating the Learning Process from a Constructivist Perspective

A. Teacher as a Facilitator:

5 = Students are responsible for their own learning experience. Teacher facilitates the learning process. Teacher-student learning experience is a partnership.

3 = Students are not always responsible for their own learning experience. Teacher directs the students more than facilitates the learning process. (Teacher-student learning experience is more teacher-centered than student-centered.)

1 = Students are not responsible for their own learning experience. Teacher directs the learning process. (Teacher-student learning experience is completely teacher-centered, i.e. teacher lectures or demonstrates and never interacts with students.)

B. Student Engagement in Activities:

5 = Students are actively engaged in initiating examples, asking questions, and suggesting and implementing activities throughout the lesson.

3 = Students are partially engaged in initiating examples and asking questions at time during the lesson.

1 = Students are almost never engaged in initiating examples and asking questions during the lesson.

C. Student Engagement in Experience:

5 = Students are actively engaged in experiences (physically and/or mentally.)

3 = Students are moderately engaged in experiences.

1 = Students are seldom engaged in experiences.

D. Novelty:

5 = Novelty, newness, discrepancy, or curiosity is used consistently to motivate learning.

3 = Novelty, newness, discrepancy, or curiosity is used sometimes to motivate learning.

1 = Novelty, newness, discrepancy, or curiosity is used occasionally or not at all to motivate learning.

E. Textbook Dependency

5 = Teacher does not depend on the text to present the lesson. Teacher and students adapt or develop own content materials for their needs.

3 = Teacher does depend somewhat on the text to present the lesson. Teacher and students make some modifications.

1 = Teacher does depend solely on the text to present the lesson. Teacher makes no modifications with students.

Category II: Content-Specific Pedagogy (Pedagogy Related to Student Understanding)

F. Student Conceptual Understanding

5 = The lesson focuses on activities that relate to student understanding of concepts.

3 = Most of the time the lesson focuses on activities that relate to student understanding of concepts.

1 = Much of the time the lesson focuses on activities that do not relate to student understanding of concepts.

G. Student Relevance

5 = Student relevance is always a focus and the lesson relates to student experiences outside the classroom.

3 = Student relevance is always a focus.

1 = Student relevance is not a focus.

H. Variation of Teaching Methods

5 = During the lesson the teacher appropriately varies methods to facilitate student conceptual understanding; i.e., discussion, questions, brainstorming, experiments, log reports, student presentations, lecture, demonstration, etc.

3 = During the lesson the teacher sometimes varies methods to demonstrate the content; i.e., discussion, questions, brainstorming, experiments, log reports, student presentations, lecture, demonstration, etc.

1 = During the lesson the teacher uses only one method to demonstrate the content; i.e., discussion, questions, brainstorming, experiments, log reports, student presentations, lecture, demonstration, etc.

I. Higher-Order-Thinking Skills

5 = Teacher consistently moves students through different cognitive levels to reach higher order thinking skills.

3 = Teacher sometimes moves students through different cognitive levels to reach higher order student thinking skills.

1 = Teacher does not move students through different cognitive levels to reach higher order thinking skills.

J. Integration of Content and Process Skills

5 = Content and process skills are integrated.

3 = Content and process skills are not integrated.

1 = Content is taught without process or process without content.

K. Connection of Content and Evidence

5 = Concepts are connected to the evidence.

3 = Concepts are partially connected to evidence.

1 = Concepts are not connected to evidence.

Category III: Context-Specific Pedagogy (Fluid Control with Teacher and Student Interaction)

L. Resolution of Misperceptions

5 = As student misperceptions become apparent, the teacher facilitates student efforts to resolve them by gathering evidence, participating in discussion with students, or fostering discussion among students.

3 = As student misperceptions become apparent, the teacher usually facilitates student efforts to resolve them by gathering evidence, participating in disucssion with students, or fostering discussion among students.

1 = As student misperceptions become apparent, the teacher does not facilitate student efforts to resolve them by gathering evidence, participating in discussion with students, or fostering discussion among students.

M. Teacher-Student Relationships

5 = Teacher consistently demonstrates good interpersonal relations with students. No differentiation is made regarding: ethnicity, gender, multi-cultural diversity, and special education classifications.

3 = Teacher does not consistently demonstrate good interpersonal relations with students most of the time. On occasion, some differentiation is made regarding: ethnicity, gender, multi-cultural diversity, and special education classifications.

1 = Teacher does not demonstrate good interpersonal relations with students. Differentiation is made regarding: ethnicity, gender, multi-cultural diversity, and special education classifications.

N. Modifications for Student - Understanding

5 = Teacher has continuous awareness of his/her student understanding and modifies the lesson when necessary.

3 = Teacher has a general awareness of student understanding and occasionally modifies the lesson when necessary.

1 = Teacher has little or no awareness of student understanding and does not modify the lesson when it is appropriate.

Category IV: Content-Knowledge (Teacher Demonstrates Excellent Knowledge of Subject Matter)

O. Use of Exemplars

5 = Exemplars and metaphors (verbal, visual, and physical) are frequently used and are accurate and relevant throughout the lesson.

3 = Exemplars and metaphors (verbal, visual, and physical) are sometimes used and are accurate and relevant some of the time.

1 = Exemplars and metaphors are rarely used and are not accurate and relevant.

P. Coherent Science Experience (Lesson)

5 = Concepts, generalizations, and skills are integrated coherently throughout the experience (lesson).

3 = Concepts, generalizations, and skills are not always integrated as a coherent organization of events throughout the experience (lesson).

1 = Concepts, generalizations, and skills are not integrated and lack coherency throughout the experience (lesson).

Q. Balance between Depth and Comprehensiveness

5 = Content has an appropriate balance between in-depth and comprehensive coverage.

3 = Lesson does not have an appropriate balance between depth and comprehensive much of the time. (Lesson has too much depth for the topic and too little coverage, or lesson has too much coverage and too little depth.)

1 = Content is shallow, incomplete, or lacking. (Lesson has neither depth nor breadth.)

R. Accurate Content

5 = Content is always evident and always accurate.

3 = Content is usually evident and mostly accurate.

1 = Content is missing or inaccurate.

ESTEEM (BURRY-STOCK, 1995)

TEACHING PRACTICES ASSESSMENT INVENTORY

(Teacher)

Instructions:

The Teaching Practices Assessment Inventory was designed as a self-report inventory to assess how much a teacher perceives the degree to which they practice classroom behaviors associated with expert teaching from a constructivist perspective. It is assumed that it is a teacher's duty to teach in such a manner as to maximize student learning. Please reflect on your classroom teaching and respond to the following statements. There are no incorrect answers; however, the more honestly you can reflect on your own teaching practices, the more meaningful the results of the inventory will be to you in your professional development

Use the following format to respond to the statements:

Almost Never (1) Seldom (2) Sometimes (3) Often (4) Almost Always (5)

1. Your students are responsible for their own learning experience. (You are a facilitator of the learning experience.)
2. Your students are actively engaged in initiating experiences.
3. Your students are actively engaged in asking questions throughout class-time.
4. Your students are actively engaged in suggestion activities throughout class-time.
5. Your students are actively engaged in implementing activities throughout class-time.
6. Your students are actively engaged in experiences (physically or mentally) throughout class-time.
7. You use novelty to motivate learning.
8. You use newness to motivate learning.
9. You use discrepancy to motivate learning.
10. You use curiosity to motivate learning.
11. You do not depend on the textbook for class experiences.
12. You and/or your students adapt content material.
13. You and/or your students develop content materials.

14. Your class time focuses on activities that relate to student understanding of concepts.
15. Student relevance is a focus of your lesson.
16. Your students have the opportunity to experience the relationship of concept(s) to their everyday lives.
17. During the lesson you appropriately vary methods to facilitate student conceptual understanding; i.e., discussion, questions, brainstorming, experiments, log reports etc.
18. You move students through different cognitive levels to reach higher order thinking skills.
19. You integrate content and process skill during a class-time.
20. You allow students to establish concepts from evidence gathered during a lesson.
21. As student misperceptions become apparent, you facilitate student efforts to resolve misperceptions i.e., gathering evidence facilitating discussion with or among students.
22. Your students are motivated to gather evidence to resolve their misconceptions.
23. You have good interpersonal relations with students.
24. You have an awareness of your students' understanding of content and modify your lesson when necessary.
25. You use exemplars that are accurate and relevant.
26. You use metaphors that are unique, accurate, and relevant.
27. You integrate concepts, generalizations, and skills coherently.
28. Your science class experiences have an appropriate balance between depth and breadth.
29. You accurately present the information in your lessons.
30. Your teacher-student learning experience is a partnership.

ESTEEM (BURRY-STOCK, 1995)

ASSESSMENT OF CLASSROOM LEARNING IN SCIENCE INVENTORY

(Teacher)

Instructions:

Science teachers are continuously involved in assessment of student learning. This inventory addresses the degree to which you feel that you are skilled in using various classroom learning assessment practices. There are no rights or wrong answers.

Record your responses on the answer sheet designed for this inventory. For each of the following statements, rate the degree to which you feel that you are skilled in implementing each of the following activities for assessing classroom learning in science. A "1" indicates that you feel that you are "NOT AT ALL SKILLED" in using the statement as an assessment of classroom learning activity. A "5" indicates that you feel that you are "HIGHLY SKILLED" in using the statement as an assessment of classroom learning activity. You may also choose any of the numbers in between "1" and "5" that best describe you. Read each statement and record the number that best represents how skilled you feel you are about using the assessment of classroom learning activity.

1. Using teacher-made paper-pencil tests.
2. Using multiple-choice questions.
3. Using matching questions.
4. Using true/false questions.
5. Using short answer questions.
6. Assigning letter grades.
7. Assigning number grades.
8. Obtaining diagnostic information from standardized norm-referenced tests for enhancing instruction.
9. Obtaining diagnostic information from standardized criterion-referenced tests for enhancing instruction.
10. Using performance measures.
11. Using concept mapping for informal assessment
12. Using concept mapping for grading purposes.
13. Using portfolios for grading purposes.
14. Implementing systematic grading procedures.

15. Implementing a grading model.
16. Developing a grading philosophy.
17. Communicating criteria to students.
18. Weighing differently projects, exams, homework, etc. when assigning semester grades.
19. Developing classroom incentive systems to enhance achievement.
20. Developing assessments that are based on clearly defined objectives.
21. Establishing student expectations for determining grades.
22. Using announced quizzes for informed feedback.
23. Incorporating homework in the grading model.
24. Using individual science reports for grading purposes.
25. Using science fair projects.
26. Using individual laboratory reports for grading purposes.
27. Using group laboratory reports for grading purposes.
28. Using systematic procedures for determining borderline grades.
29. Using group oral discussion for informal assessment.
30. Using teacher student oral discussion for informal assessment.
31. Using group or participation for informal assessment.
32. Enhancing student motivation for learning.
33. Providing timely written feedback.
34. Providing immediate oral feedback.
35. Incorporating extra credit activities in the calculation of grades.
36. Using oral questions from students for informal assessment.
37. Using laboratory/activity worksheets for grading purposes.
38. Using individual hands-on activities for informal assessment.
39. Using group hands-on activities for informal assessment.
40. Using individual class presentations for grading purposes.
41. Using group class presentations for grading purposes.
42. Using the end-of-chapter questions for enhancing student understanding.
43. Using teacher observations for informal evaluation.
44. Incorporating hands-on activities for enhancing student understanding.
45. Incorporating computer projects for enhancing student understanding.
46. Incorporating computer exercises for grading purposes.

47. Using class review questions for enhancing student understanding.
48. Choosing appropriate assessment methods for grading purposes.
49. Using assessment results when making decisions (instructional, placement, and promotion) about individual students.
50. Using assessment results when planning teaching.
51. Using assessment results in curriculum development.
52. Using formal assessment results when evaluating class improvement.
53. Communicating assessment results to students.
54. Communicating assessment results to parents.
55. Recognizing unethical, illegal, and otherwise inappropriate assessment methods.
56. Recognizing unethical, illegal, and otherwise inappropriate assessment uses of assessment information.
57. Communicating grading expectations.

ESTEEM (BURRY-STOCK, 1995)

STUDENT OUTCOME ASSESSMENT RUBRIC

Instructions:

The Student Questions and the accompanying rubric Student Outcome Assessment Rubric are companions to the Classroom Observation Rubric. Student Questions should be administered with every classroom observation that is to be evaluated using the Classroom Observation Rubric to provide student data for one lesson. These questions may also be used alone to obtain student feedback.

Student Questions should be administered at the end of a daily lesson. The following directions are to be read by the evaluating teacher who may be the teacher, a peer, or an external evaluator.

"I would like very much if you would give us some information about today's class. There are three questions for you to answer on this sheet of paper."

Pass out a set of Student Questions to every student.

"What you say is important; please take a minute to think through your answers."

Name:____________________________ Date:__________________________

Teacher:__________________________ Grade:_________________________

1. What do you think your teacher wanted you to learn today (what was the main idea)?

2. List some questions that today's lesson made you want to ask?

3. How is this topic important to you?

ESTEEM (BURRY-STOCK, 1995)

STUDENT OUTCOME ASSESSMENT RUBRIC

Instructions:

The ratings for all three questions are anchored at levels "5," "3," and " 1" with descriptors that are the criteria for scoring student responses. If a student's response is described by a " 1" level description, the student receives a "5." If the response is best described by a "3" level description, the student receives a "3." However, if the student response would be better described somewhere between a "5" and a "3," the student score should be a "4." A "2" rating would fall between a "3" and a "1." Ratings of "4" and "2" should be used when the student response is best described by criteria between "5" and "3" and "3" and "1" respectively.

A. Capturing the Main Idea

Coding addresses whether or not the student captured the main idea as it was presented during the lesson.

5 = The response states the main idea and provides details, descriptions, or explanations that indicate the student did not just copy or regurgitate the main idea. The response indicates the student understood the big picture surrounding the main idea. Response may go beyond the idea as discussed in class.

3 = The response states the main idea, with no elaboration. The statement may appear to be book-related.

1 = The student's response has little or no relationship to the main point of the lesson. The response is about a different topic or an aspect of the broader topic. For example, humans have two arms should be rated 1 if the lesson was about the endocrine system.

B. Student Inquiry

Coding addresses the relationship of the student's question(s) to the lesson. Was the question one that was addressed during the lesson but the student did not understand, or was it a question that arose out of the lesson but could not be answered from material addressed? Was it a fairly straightforward question or was it an imaginative question?

5 = The student asks an abstract question that relates to a part of the lesson, but the answer was not provided during the lesson. The question may be complex,

multifaceted. The question might be a "what if or a "how do we know" kind of a question, for example. The question relates to the big picture of the lesson, but the answer was not provided during class.

3 = The student asks a concrete question that relates to the lesson, but the answer was not provided during the lesson. The question could be answered with a yes/no, a fairly simple fact, or set of facts. The question calls for an explicit answer. Example: How many bones does a bird have? The question may appear to be book-related.

1 = The student indicates he/she did not understand, has no questions, or the question does not relate at question is not related to the lesson at all—to any part of the lesson—it addresses a totally different topic, but it is related to science. For example, a question about dogs when the topic was planets.

C. Student-Relevance

Coding addresses whether or not the student was able to make the class material relevant to his/her life.

5 = The student states in detail that content from the lesson is important to some aspect of society.

3 = The student in some way states that the content is tied to something relevant in his/her life.

1 = The student comments about the lesson, but does not make it relevant to his or her life or to society.

ESTEEM (BURRY-STOCK, 1995)

CONCEPT MAPPING RUBRIC (Students)

Instructions:

The Concept Mapping Rubric is an analytical scoring guide used to evaluate student concept maps. Concept mapping should be taught and practiced by students before it is used for evaluation. It may be employed as a diagnostic tool for pre-teaching to capture students' level of conceptual understanding of the topic. A formal administration of the Concept Mapping Rubric is done at the end of a unit of study. It may be used, if previously taught, as a substitution for a unit test, thus, making it an alternative summative measure.

The Concept Mapping Rubric is the criterion for scoring the concept maps. Student concept maps are to be compared with the descriptions on the scoring guide. If the student's response is best described by the "5" level description, then the rating should be a "5." If the student's response is best described by a "3" level description, then the rating should be a "3." However, if the student's response would be best described somewhere between a "5" and a "3", then a "4" rating should be used. A "2" rating would fall somewhere between a "3" and a " 1." The Concept Mapping Rubric uses approximate percentages. For example, the "5" rating is described as "ninety percent or more," and the "3" rating is described as "seventy percent or more," and the "1" rating is described as "fifty percent or less." When the approximate percentage is 80, a "4" rating should be used and when the approximate percentage is 60, then a "2" rating should be used. It may be easier to use the Concept Mapping Rubric by writing on the students' work. Ratings should be recorded on the accompanying answer sheet. Examples are included in the administration, Scoring, and Interpretation Manual. Evaluators should practice the scoring procedures before a formal evaluation is done.

The ESTEEM concept mapping rubric consists of five categories: Key and non key words, lines, meaningful connections, meaningful segments, and meaningful total pattern. Using an oblique rotation, the five categories were assembled through a principal component facto analysis which resulted in five factors (categories) that accounted for 86% of the variability (Bury Stock, 1995).

For example: an excerpt of category 3: meaningful connections from the ESTEEM concept Mapping Rubric Follows:

Category 3: Meaningful Connections

A. Connecting lines are labeled with a word or symbol:

5 = connecting lines are labeled with a word or symbol approximately 90% or more of the time

3 = connecting lines are labeled with a word or symbol approximately 70% or more of the time

1 = connecting lines are labeled with a word or symbol approximately 50% or more of the time

B. Connections meaningful:

5 = the relationships between the concepts are meaningful approximately 90% or more of the line

3 = the relationships between the concepts are meaningful approximately70% or more of the line

1 = the relationships between the concepts are meaningful approximately 50% or more of the line

Competency level descriptors are expert, proficient, competent, advanced beginner, and novice. The respective cut points for these levels are 85%, 70%, 35%, 15%, and 1%.

The Learning Style Inventory (LSI)*

The Learning Style Inventory describes the way you learn and how you deal with ideas and day-to-day situations in your life. Below are 12 sentences with a choice of endings. Rank the endings for each sentence according to how well you think each one fits with how you would go about learning something. Try to recall some recent situations where you had to learn something new, perhaps in your job or at school. Then, using the spaces provided, rank a "4" for the sentence ending that describes how you learn *best*, down to a "1" for the sentence ending that seems least like the way you learn. Be sure to rank all the endings for each sentence unit, using each number only once. Please do not allot the same number to two items.

Example of completed sentence set:

When I learn:

1 I am happy. 3 I am fast. 2 I am logical. 4 I am careful.

Remember:

4 = *most* like you 3 = *second most* like you 2 = *third most* like you 1 = *least* like you

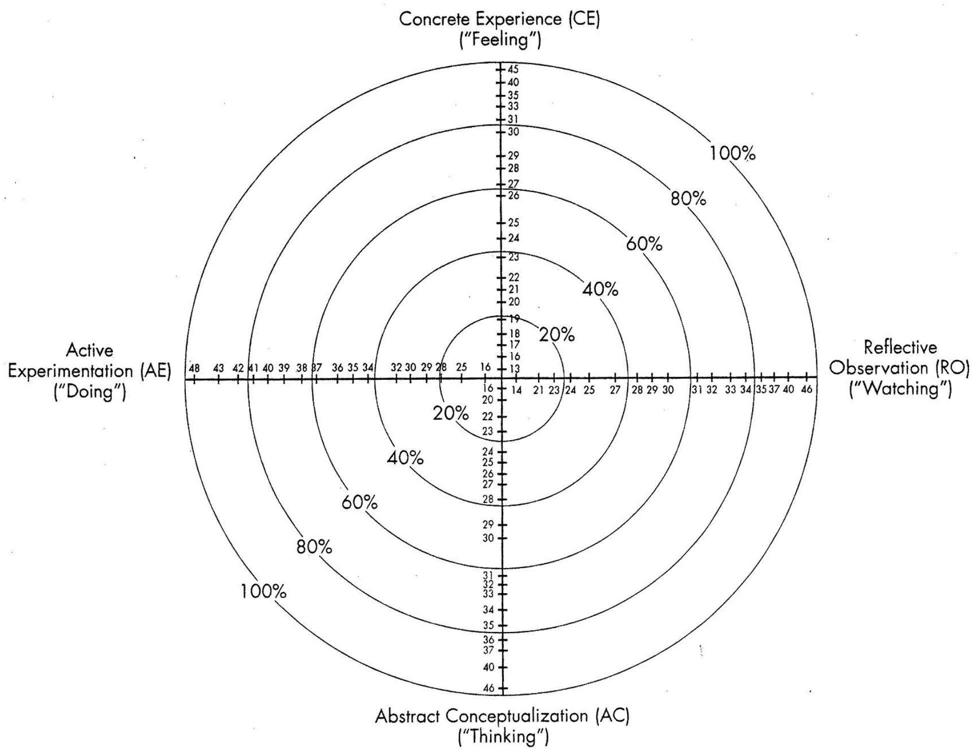
	A		B		C		D	
1. When I learn:	___	I like to deal with my feelings.	___	I like to think about ideas.	___	I like to be doing things.	___	I like to watch and listen.
2. I learn best when:	___	I listen and watch carefully.	___	I rely on logical thinking.	___	I trust my hunches and feelings.	___	I work hard to get things done.
3. When I am learning:	___	I tend to reason things out.	___	I am responsible about things.	___	I am quiet and reserved.	___	I have strong feelings and reactions.
4. I learn by:	___	feeling.	___	doing.	___	watching.	___	thinking.
5. When I learn:	___	I am open to new experiences.	___	I look at all sides of issues.	___	I like to analyze things, break them down into their parts.	___	I like to try things out.
6. When I am learning:	___	I am an observing person.	___	I am an active person.	___	I am an intuitive person.	___	I am a logical person.
7. I learn best from:	___	observation.	___	personal relationships.	___	rational theories.	___	a chance to try out and practice.
8. When I learn:	___	I like to see results from my work.	___	I like ideas and theories.	___	I take my time before acting.	___	I feel personally involved in things.
9. I learn best when:	___	I rely on my observations.	___	I rely on my feelings.	___	I can try things out for myself.	___	I rely on my ideas.
10. When I am learning:	___	I am a reserved person.	___	I am an accepting person.	___	I am a responsible person.	___	I am a rational person.
11. When I learn:	___	I get involved.	___	I like to observe.	___	I evaluate things.	___	I like to be active.
12. I learn best when:	___	I analyze ideas.	___	I am receptive and open-minded.	___	I am careful.	___	I am practical.

* *The Learning Style Inventory* is based on several tested theories of thinking and creativity. The ideas behind assimilation and accommodation originate in Jean Piaget's definition of intelligence as the balance between the process of adapting concepts to fit the external world (accommodation) and the process of fitting observations of the world into existing concepts (assimilation). Convergence and divergence are the two essential creative processes identified by J. P. Guilford's structure-of-intellect model.

Scoring the LSI: Enter your scores for each sentence completion in the correct space. For example, for item #1, if you ranked the first sentence completion option ("I like to deal with my feelings") as a 4, write a 4 in the first space above 1A. Next write the number you gave to 2C. Do that for the rest of your responses. Then add up the scores in each row to obtain your total for each dimension. Read The Knowledge Base for information on how to interpret your scores.

___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___	= ☐
1A	2C	3D	4A	5A	6C	7B	8D	9B	10B	11A	12B	CE Total
___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___	= ☐
1D	2A	3C	4C	5B	6A	7A	8C	9A	10A	11B	12C	RO Total
___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___	= ☐
1B	2B	3A	4D	5C	6D	7C	8B	9D	10D	11C	12A	AC Total
___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___ +	___	= ☐
1C	2D	3B	4B	5D	6B	7D	8A	9C	10C	11D	12D	AE Total

Plot your score for each learning mode on the graph below. Then connect these points to form a kite-like figure. To compare your score with others, look at the percentile rings. For example, if you had a score of 27 on Concrete Experience (CE), your score would be higher than 60% of those who scored at this level in the validation studies of this instrument.



The Cycle of Learning

Source: Reprinted from *The Kolb Learning Style Inventory, Version 3* (1999) by permission of the Hay Group, 116 Huntington Avenue, Boston, MA 02116.

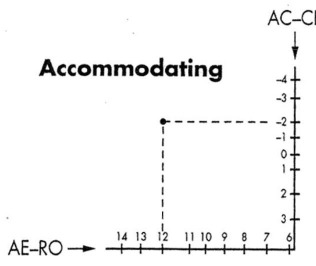
While your kite shape explains your relative preferences for the four modes or phases of the learning cycle, your combined scores will explain which of the four dominant learning styles best describes you. Take your scores for the four learning modes, AC, CE, AE, and RO, listed on the previous page, and subtract as follows to get your two combination scores:

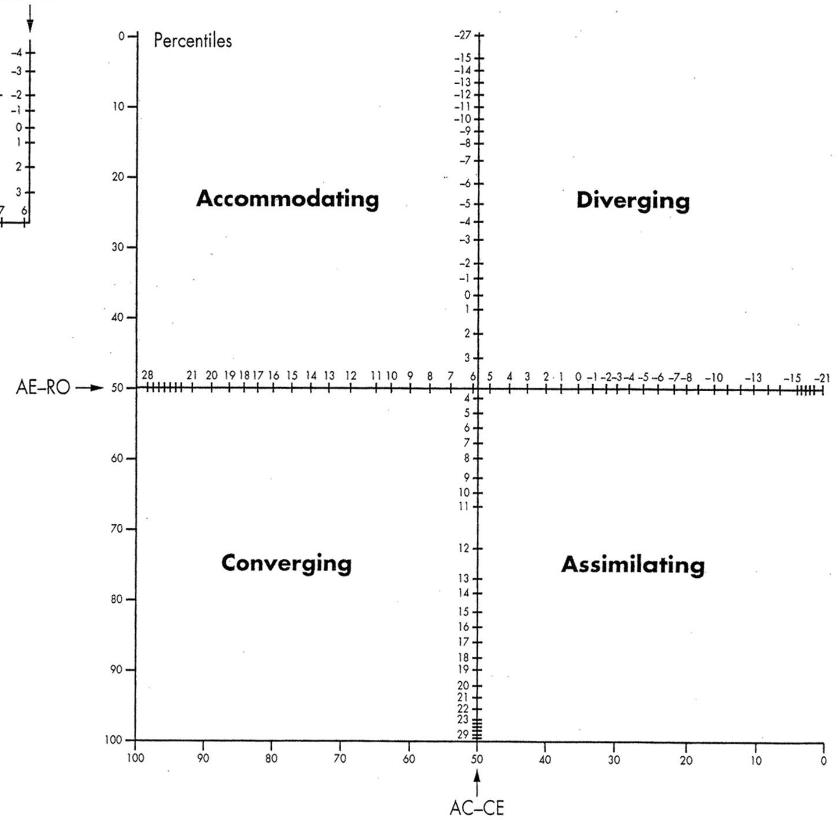
AC – CE = AC–CE

AE – RO = AE–RO

Next, plot these scores on the grid below to locate your data point. The closer your data point is to the center of the grid, the more balanced your learning style. If the data point falls near any of the far corners of the grid, you tend to rely heavily on that particular learning style. You can compare your score to those of other people using the percentile marks. Please read the descriptions of these styles and their strengths in the following pages.

Example: if your AC–CE score is –2 and your AE–RO score is +12, your style falls into the Accommodating quadrant, as shown below.





Learning Style Type Grid

Source: Reprinted from *The Kolb Learning Style Inventory, Version 3* (1999) by permission of the Hay Group, 116 Huntington Avenue, Boston, MA 02116. No part of the LSI instrument or information may be reproduced or transmitted in any form or by any means, without permission in writing from the Hay Group.

A SHELTERED INSTRUCTION MODEL FOR ACADEMIC ACHIEVEMENT

<table>
<tr><th colspan="6">Preparation</th></tr>
<tr><td>Clear Content:</td><td>Clear Language Objectives:</td><td>Content Concepts:</td><td>Supplementary Materials:</td><td>Adapting Content and Text to Meet Student Needs:</td><td>Meaningful Activities:</td></tr>
<tr><th colspan="6">Building Background</th></tr>
<tr><td colspan="2">Link to Student Background/Experience:</td><td colspan="2">Link to Past Learning /Concepts:</td><td colspan="2">Build and Strengthen Key Vocabulary:</td></tr>
<tr><th colspan="6">Comprehensible Input</th></tr>
<tr><td colspan="2">Sensitivity to Specialized Vocabulary Speech:</td><td colspan="2">Explicit Description of Academic Tasks:</td><td colspan="2">Varied Instructional Strategies/Techniques:</td></tr>
<tr><th colspan="6">Learning Strategies</th></tr>
<tr><td colspan="2">Meta-cognition /Cognitive Learning Strategies:</td><td colspan="2">Scaffolding Techniques:</td><td colspan="2">Variety of Questions Used for Higher Order Thinking:</td></tr>
<tr><th colspan="6">Interaction (Social Affective Learning)</th></tr>
<tr><td colspan="2">Provide Multiple Opportunities for Interactions:</td><td>Use Multiple Group Configurations:</td><td>Allow for Wait Time:</td><td colspan="2">Give Opportunities to Clarify Key Concepts in First Language:</td></tr>
<tr><th colspan="6">Practice Application</th></tr>
<tr><td colspan="2">Provide Multiple Hands On Opportunities:</td><td colspan="2">Apply Content and Language Objectives:</td><td colspan="2">Integrate Language Skills:</td></tr>
<tr><th colspan="6">Lesson Delivery</th></tr>
<tr><td colspan="2">Content Objectives Supported by Lesson Delivery:</td><td>Language Objectives Supported by Lesson Delivery:</td><td>Students Engaged 90% of Period:</td><td colspan="2">Pacing Appropriate to Ability Level:</td></tr>
<tr><th colspan="6">Review Assessment</th></tr>
<tr><td colspan="2">Review Key Vocabulary:</td><td>Review Key Concepts:</td><td>Give Feedback to Students:</td><td colspan="2">Provide a Variety of Appropriate Assessments:</td></tr>
</table>

A CHECKLIST TO OBSERVE STUDENTS' PERCEPTIONS AND EXPERIENCES OF THE LEARNING STRATEGIES

Integrated Framework			
Constructivist principles	Yes	Limited	No
1. Learning process should enable learners to actively engage with and manipulate the learning content.			
2. Instructional material must allow learners to construct knowledge and meaning.			
3. Knowledge is constructed within a social context; this will enable learners to explore viewpoint of others and to collaborate in the learning process.			
4. Learning content must engage learners in solving complex and ill-structured problems, as well as simple problems.			
5. Contextual material should permit interpretation, argumentation and transference of ideas to different contextual platforms.			
6. During and after the learning process, learners should be able to articulate what they learnt and reflect on the process for better understanding.			
7. Learners have to see the relevance of knowledge and skills to their lives, and they must be able to solve authentic problems in new situations.			
8. The design of the learning environment ought to empower learners to interpret the learning material in any given context.			
9. Learners must be given the opportunity to be engaged with the content and to learn from different perspectives for a richer and better understanding.			
Generic learning design principles	Yes	Limited	No
1. The presentation of learning tools must be kept consistent throughout the application.			

2. The presentation of the interface must be relatively simple and easy to follow for effective learning. 3. The learner must initiate and control action, and must have the sense of mastery over the tools, rather than being under the control of the teacher. 4. Informative and appropriate feedback must be provided for the progress made throughout the presentation. 5. Due to human short-term memory, learners must be allowed to organize content more than to recall. 6. The material provided to the learner must be familiar to them so as to evoke their prior knowledge. 7. Information presented on the screen should be logical, followed by expectations of user and task requirements. 8. Learners should always get help: either procedural help for the program or information help within the content. 9. Users of the design must have instant access to the functions they use and features that help to escape or end their current session.			
Learning style views	Yes	Limited	No
1. The learner is actively involved in carrying out tasks and plans, as well as being involved in concrete new experiences through action. 2. In the learning process, the learner is able to view concrete situations from different perspectives through observation rather than action. 3. The learner is able to reason inductively, and creates theoretical/conceptual models into an integrated explanation. 4. In the learning environment, the learner should be able to reason and solve practical problems. 5. The learning environment should enable the learners to acquire theoretical knowledge and apply it practically.			

6. The learner is actively involved in new experiences as well as decision making in solving practical problems. 7. Learners should be able to organize learning content into a meaningful whole in order to create theoretical models.			

SOME OBSERVATION PROTOCOLS RECORDED DURING THE STUDY

Observation Protocol I

Chapter: The Electricity and Magnetism Topics: The Circuits

School: The Trust School Day: First

The room is full of enthusiasm as the teacher enters the class with some teaching materials. The teacher passes out books, laboratory instruments, magnets, electric wires, cells, etc. The students ask to predict what would happen if they join the wire in cells and with a bulb? Students look at each other and without any reply, the teacher says, “Would it glow?” One student raises her hand and asks if there is anything in the cell. The teacher comments, “You tell me.” Students are then given the opportunity to decide how to join the connections.

Students discuss how they would place things in a circuit. After doing this they have to decide if the bulb would glow. Each group does complete opposites; not one group follows the same pattern. One group places the bulb in the open circuit and then makes switch on to see if the bulb would glow. Another group directly connects the wires to see glowing without switch. One student from that group comments, “Would the circuit work without switch or what is the use of switch then?” One of his partners say, “Not all of the circuits need switch to see the glowing but we should use switch to control the electricity whenever we need.” Students try to invert the cell but the glowing effect remains same. Some of the students are using words such as, 'open' or 'close' and 'bright'. The teacher keeps walking around here and there. The students know not to ask for the answer to the problem.

The students had to design and build a circuit, and electro magnet that functioned. Meanwhile the science teacher showed audio visual show so that the students could see these things look like. The audio visual that were selected for the students viewing were CD of Midas Company. The teacher said, “This is basically what I want, how can you build a series of events to do the simplest things?” Each group had to provide its own materials for this lesson. The teacher repeated the show so that students could follow the instructions.

In fact, the teacher worked only as a consultant. He would provide input but he did not answer directly. Whole period, the students would run trial after trial testing their events to make sure that it would address a simple step procedure. The students recorded each step in the note book checking for consistency, fluency and error. Each group constructed completely different models of circuits, and electromagnets. The teacher stressed to each group that each event must be separate. He would walk around having the students justify why they felt they met each criterion. Only two groups passed all the requirements. Two other groups had partial completion, and one group had done a little. No one was with any sorrow even after their event did not meet the exact criteria of all requirements. The students seem happy that they had a successful operation after all. At the end, the students commented that this is our class and we made ourselves learning. We are proud of having such enjoyable class and also demand in other subjects as well.

Observation Protocol II

Chapter : Chemistry Topics: The Chemical Bonding

School : The Institutional School Day: First

The teacher began with the introduction to the lesson by talking about something they had explored earlier in the school year, 'Atoms and Molecules'. Students were asked if they remembered anything about atoms (Students raised their hands and answered). The teacher continued his discussion by saying, “When we think of how things bond together, I want you to give me some examples of what bonding means. Now write it down and talk about it with one another (students began to write and discussed what bonding is).” “Now share with me what you think bonding is.”

One student said “Bonding is my football team. We have to bond together to function as a group.” The teacher smiled and told her great job. He then asked for further participation from the group. A student shared how bonds are like sticky matter that clump together. The teacher said, “Exactly.” He then asked “If I gave you starch, glue, water, beakers, and corn starch, would this be a bonding activity? I want you to be able to explain to me if this is: a bonding activity, a physical reaction, or a chemical reaction. Can anyone tell me if you can undo a chemical reaction?” The teacher passed out the materials and let the students explore. Students mixed and created a globe like substance. As he walked around the room he asked the students, “Do you think all of these materials have bonded together? Can we undo this bonding relationship? Why or Why not?” Students began to share-explaining that everything stuck or bonded together because of the chemical reaction involved.

The teacher was busy on helping students understand the concept of bonding and the difference between a chemical change and a physical change. He talked about his experiences as a field geologist and how chemical bonds relate to oil. He said, "Have you ever seen your mother cooking with oil?" The teacher shared an example of a previous experience and then led the students into a discussion about the materials on their laboratories. He asked the students what would happen if they mixed the materials together. What would they see? The students began to mix the materials with their hands. The student’s hands became sticky and white. The teacher was using this as an example to show students how items can be bonded together and changed. The teacher asked, "Is this a physical or chemical reaction? Can this be undone? Can cooked oil become uncooked? What is a physical or chemical reaction?" The ultimate exercise of the teacher demonstrated coherent science experience.

Here is an excerpt of some students’ role play demonstration in the class:

Two students came to class with outside information on a science contest and with new ideas they could incorporate into their six step procedure.

Step 1: First one showed clay in her hand.

Step 2: She rolled two clay balls and showed to the class.

Step 3: Second one handled a stick in his hand.

Step4: The first one joined the clay balls at the two ends of the stick.

Step 5: She also made a diagram of the structure they made in the black board.

Step 6: two other students added the similar diagram of bonding of different elements.

Each group of students understood how to build a bond structure through the concepts being taught. The evidence was a completed diagram.

Observation Protocol III	
Chapter: Taxonomy	Topics: The Plant Classification

School: The Trust School Day: Fifteenth

The black board read, “Using the materials in front of you, how can you create a chart of plant succession on development?” List of materials: algae, fungi, bryophytes, pteridophytes, gymnosperms, and angiosperms.

The teacher provided students with pictures he had taken from different parts of the country. Students examined the photographs through projector. There were examples of previous student work, illustrations of learning, achievement, and quality in relation to the levels of science being taught in the teacher’s classroom hanging on the walls. Students also were responsible for creating their own examples and metaphors. The teacher and the students used verbal analogies and metaphors such as comparing a chemical bond to bonding like glues that got sticky and clumped together. Visual, verbal, and physical examples and models from current students were examined in a group atmosphere.

The students were then asked to search different plants in the garden outside the classroom. They moved in group and collected different specimens from the garden. They all came back in the class and together they tried to put plants matching with their characteristics. After all they came up with successive classified group of plants with some posters. At last they realized about the plant succession.

Observation Protocol IV

Chapter : Geology Topics: The Atmosphere

School : The Community School Day: Twelfth

The teacher entered into the class with multimedia projector and some CDs about the audio-visual documents. The students were feeling curious about the devices and the activities the teacher was going to perform. There were no audio-visual facilities and the teacher managed from somewhere for this class.

As the wires and plugs connected, the teacher announced, "Today I am going to show you the visuals of the climate and atmosphere of the earth. You may find the interesting scenarios of the atmosphere, water cycle, land breeze and sea breeze as well. The following conversation and discussion of the teacher and the students were observed during and after the show:

A student: How do we know that an event is actually one event and not several?

The teacher: Excellent question, lets go back to the visual clips and I can go over each step with you. What I want from you is to identify when a step ends and a new step begins in the natural cycle.

(The teacher ran the audio visual clips and the students watched.)

Another student: There, that is a new step.

The teacher: why?

The student: Because it is a different step.

The teacher: Now I am going to show it to you in slow motion so that you will be sure that the step changes.

The teacher slowed the visual down and students watched each step that took place. Actually the lesson was about the different changes that happening in the different layers of atmosphere. The visuals showed the water cycle, land breeze as well as sea breeze. The students observed the ozone layer in the documentary film. As the community school had no regular audiovisual facility to show.

RESULT OF CONSTRUCTIVIST LEARNING SURVEY -2008

CATEGORY: TRUST SCHOOL

SN	School of the Participant Teacher	Address	Qualification	Teaching Experience	Score Obtained
1	Anandakuti Sec. School	Kathmandu	MSc	10 yrs	56
2	St. Xaviers School	Lalitpur	MSc	15 yrs	67
3	St Marry's School	Lalitpur	MSc	10 yrs	76
4	Bhanubhakta Memorial Sec School	Kathmandu	MEd	5 yrs	63
5	Siddartha Vanasthali Institute	Kathmandu	MSc	12 yrs	55
6	Laboratory Sec. School	Kathmandu	BSc	3 yrs	67
7	SOS Hermangmiener School	Bhaktapur	MSc	15 yrs	87
8	Budhanilkhanta Sec School	Kathmandu	MSc	5 yrs	73
9	Adarsha Vidya Mandir	Lalitpur	BSc	10 yrs	72
10	Viswoniketan Sec. School	Kathmandu	MSc, BEd	5 yrs	74
11	Marygold Academy	Jhapa	IA	2 yrs	45
12	Green Vale Academy	Jhapa	BSc	1 yr	56
13	Oasis Academy	Jhapa	BA	4 yrs	57
14	New horizon Academy	Jhapa	IEd	2 yrs	68
15	Sunrise Academy	Jhapa	IA	1yrs	54
16	Tri-Ratna Secondary School	Jhapa	BSc	3 yrs	54
17	Preran Mahila Sec. School	Lalitpur		2 yrs	65
18	Dorjee Secondary School	Kathmandu	BSc	8 yrs	76
19	Blooming Lotus Eng. School	Jhapa	MA	1 yr	45
20	Birendra Sainik School	Bhaktapur	MSc	6 yrs	57
21	Khowpa Secondary School	Bhaktapur	BSc	4 yrs	46
22	Martyr's Memorial Sec. School	Kathmandu	BSc	8 yrs	56
23	Himalaya Vidya Mandir	Kathmandu	MSc	5 yrs	76
24	Samata Sikshya Niketan	Kathmandu	BSc	2 yrs	67
25	Pashupati Sikshya Mandir	Kathmandu	BSc	3 yrs	62
26	Baba Secondary School	Kathmandu	Bed	9 yrs	56
27	Mahendra Adarsha School	Lalitpur	MSc	13 yrs	34
28	Tribhuvan Adarsha B. Sec. School	Kathmandu	MSc	6yrs	76
29	Hindu Vidya Peeth Nepal	Lalitpur	BSc	3 yrs	65
30	I. J. Pioneer Sec. School	Kathmandu	BSc	4 yrs	60
31	Gandaki Boarding School	Kaski	MSc	6 yrs	76
32	Naulojyoti Eng. School	Bhaktapur	MSc	10 yrs	77
33	Paropakar Adarsha Sec. School	Kathmandu	BSc	11 yrs	67
34	Mahendar Bhaban Kanya Sec. School	Kathmandu	BSc	14 yrs	66
35	Jyoti Academy	Lalitpur	BSc	6 yrs	63

CATEGORY: COMMUNITY SCHOOL

SN	School of the Participant Teacher	Address	Qualification	Teaching Experience	Score Obtained
1	Bhadrapur Sec. School	Jhapa	MSc	6 yrs	73
2	Dhulabari Sec. School	Jhapa	MSc	4 yrs	72
3	Bhrikuti Sec. School	Jhapa	MSc	8 yrs	74
4	Tribhuvan Sec. School	Jhapa	MEd	5 yrs	45
5	Gyanjyoti Sec. School	Jhapa	MSc	2 yrs	56
6	Sanischare Sec. School	Jhapa	BSc	3 yrs	57
7	Shanti Adarsha Sec. School	Jhapa	MSc	9 yrs	68
8	Chetana Sec. School	Jhapa	MSc	13 yrs	54
9	Kusheshwor Vidyapeeth	Sindhuli	BSc	6yrs	54
10	Kalidevi Sec. School	Sindhuli	MSc, BEd	3 yrs	65
11	Janajyoti Sec. School	Sindhuli	IA	4 yrs	76
12	Bhawani Sec. School	Sindhuli	BSc	6 yrs	45
13	Kausika Sec. School	Sindhuli	BA	10 yrs	57
14	Chandrawati Sec. School	Sindhuli	IEd	11 yrs	46
15	Mangalodaya Sec. School	Kathmandu	IA	14 yrs	56

16	Prabhat Sec. School	Kathmandu	BSc	6 yrs	76
17	Koteshwor Saraswoti Sec. School	Kathmandu	BEd	6 yrs	67
18	Bal Sewa Sec. School	Kathmandu	BSc	4 yrs	62
19	Siddi Ganesh Sec. School	Kathmandu	MA	8 yrs	56
20	Tyoud Sec. School	Kathmandu	MSc	15 yrs	88
21	Kirtipur Sec. School	Kathmandu	BSc	2 yrs	76
22	Gyanodaya Sec. School	Kathmandu	BSc	3 yrs	65
23	Kanti Bhairab Sec. School	Kathmandu	MSc	9 yrs	60
24	Birethati Sec. School	Kaski	BSc	13 yrs	76
25	Kalika Sec. School	Kaski	BSc	6yrs	77
26	Mahendra Sec. School	Kaski	Bed	3 yrs	67
27	Bishnu Paduka Sec. School	Kaski	MSc	4 yrs	66
28	Siddha Sec. School	Kaski	MSc	6 yrs	63
29	Jana Jagriti Sec. School	Kaski	BSc	10 yrs	73
30	Tribhuvan Shanti Sec. School	Kaski	BSc	11 yrs	72
31	Shanti Sec. School	Kaski	MSc	14 yrs	74
32	Amarshidda Namuna Sec. School	Kaski	MSc	6 yrs	45
33	Panchodaya Sec. School	Kailali	BSc, BEd	6 yrs	56
34	Arunodaya Sec. School	Kailali	BSc	4 yrs	57
35	Janata Sec. School	Kailali	BSc	8 yrs	68
36	Sharada Sec. School	Kailali	BSc	5 yrs	54
37	Raghunath Adarsha Sec. School	Kailali	Bed	2 yrs	54
38	Dhangadhi Sec. School	Kailali	MSc	3 yrs	65
39	Ganesh Sec. School	Bhaktapur	MSc	9 yrs	76
40	Basu Higher Sec. School	Bhaktapur	BSc	13 yrs	45
41	Adarsha Sec. School	Bhaktapur	BSc	6yrs	57
42	Saraswati Sec. School	Bhaktapur	MSc	3 yrs	46
43	Navajyoti Sec. School	Bhaktapur	MSc	4 yrs	56
44	Sarada Sec. School	Bhaktapur	BSc	6 yrs	76
45	Vidyarthi Niketan Sec. School	Bhaktapur	BSc	10 yrs	67
46	Kanya Sec. School	Bhaktapur	BSc	11 yrs	92
47	Arniko Sec. School	Bhaktapur	BSc	14 yrs	56
48	Shramik Shanti Sec. School	Lalitpur	Bed	6 yrs	34
48	Kent Sec. School	Lalitpur	MSc	6 yrs	76
49	Mahendra Bhrikuti Sec. School	Lalitpur	MSc	4 yrs	65
50	Mahalaxmi Sec. School	Lalitpur	BSc	8 yrs	60
51	Madan Smarak Sec. School	Lalitpur	BSc	5 yrs	76
52	Adarsha Saul Sec. School	Lalitpur	MSc	2 yrs	77
53	Bal Vinod Sec. School	Lalitpur	MSc, MEd	3 yrs	67
54	Shree Krishna Sec. School	Lalitpur	BSc	9 yrs	66
55	Tribhuvan Trisulil Sec. School	Nuwakot	BSc	13 yrs	63
56	Kalika Devi Sec. School	Nuwakot	BSc	6yrs	76
57	Bhairab Sec. School	Nuwakot	BSc	3 yrs	77
58	Chandeshwori Sec. School	Nuwakot	Bed	4 yrs	67
59	Janagyan Niketan Sec. School	Nuwakot	MSc	6 yrs	66
60	Mahadev Sec. School	Nuwakot	MSc	10 yrs	63
61	Shakti Sec. School	Nuwakot	BSc	11 yrs	76
62	Dupcheshwor Sec. School	Nuwakot	BSc	14 yrs	67

CATEGORY: INSTITUTIONAL SCHOOL

SN	School of the Participant Teacher	Address	Qualification	Teaching Experience	Score Obtained
1	Mount Everest Sec. School	Jhapa	BSc	6 yrs	73
2	Dhrubatara Residential Sec. School	Jhapa	Bed	4 yrs	72
3	Siddartha Sisu Sadan School	Jhapa	MSc	8 yrs	74
4	Suryodaya English Boarding School	Jhapa	MSc	5 yrs	45
5	North Point Eng. School	Jhapa	BSc	2 yrs	56
6	Global Educational Academy	Jhapa	BSc	3 yrs	57
7	Himalaya English Academy	Jhapa	MSc	9 yrs	68

8	Gyan Jyoti Eng. School	Jhapa	MSc	13 yrs	54
9	Bhagabati Eng. School	Sindhuli	BSc	6yrs	54
10	Pragatishil Sec. School	Sindhuli	BSc	3 yrs	65
11	Prabhat Eng. School	Sindhuli	BSc	4 yrs	76
12	Ganesh Sec. School	Sindhuli	BSc	6 yrs	45
13	Himalayan Academy	Sindhuli	Bed	10 yrs	57
14	Kamalamai Sec. School	Sindhuli	MSc	11 yrs	46
15	VS Niketan Higher Sec. School	Kathmandu	MSc	14 yrs	56
16	Holy Garden HS School	Kathmandu	BSc	6 yrs	76
17	Rayners Res. Sec. School	Kathmandu	BSc	6 yrs	67
18	Siddhartha Vidyapeeth	Kathmandu	MSc	4 yrs	52
19	Kathmandu Valley	Kathmandu	MSc	8 yrs	56
20	Himalaya Higher Sec Eng. School	Kathmandu	BSc	12 yrs	85
21	Jubiliant Sec. School	Kathmandu	BSc	2 yrs	76
22	Deepseekha Sec School	Kathmandu	BSc	3 yrs	65
23	Basanta Ritu Sec. School	Kathmandu	BSc	9 yrs	60
24	Green Valley Sec School	Kaski	Bed	13 yrs	76
25	New Millineum Sec School	Kaski	MSc	6yrs	77
26	Gauri Shankar Eng School	Kaski	MSc, BEd	3 yrs	67
27	Golden Future Eng School	Kaski	BSc	4 yrs	66
28	Kumudini Homes Sec School	Kaski	BSc	6 yrs	63
29	Kanchanjungha Eng School	Kaski	MSc	10 yrs	73
30	Rainbow Academic Homes	Kaski	MSc	11 yrs	72
31	Fistail Eng. Boarding School	Kaski	BSc	14 yrs	74
32	Little Daffodil Eng School	Kaski	BSc	6 yrs	45
33	Bhaskar Memorial Eng School	Kaski	BSc	6 yrs	56
34	Karuna Nidhi Eng School	Kaski	BSc	4 yrs	57
35	Green Valley Sec School	Kaski	Bed	8 yrs	68
36	Bhanubhakta Sishu Sec School	Kaski	MSc	5 yrs	54
37	Kantipur Eng School	Kaski	MSc	2 yrs	54
38	Motherland Sec School	Kaski	BSc	3 yrs	65
39	Saraswoti Eng School	Kailali	BSc	9 yrs	76
40	Malika Eng School	Kailali	MSc	13 yrs	45
41	Stepping Stone Sec School	Kailali	MSc	6yrs	57
42	United Scholar's Academy	Kailali	BSc	3 yrs	46
43	Arniko Eng. Boarding School	Kailali	BSc	4 yrs	56
44	Siddhartha Sishu Sadan	Kailali	BSc	6 yrs	76
45	Chandrodaya Eng School	Kailali	BSc	10 yrs	67
46	Janata Eng School	Kailali	Bed	11 yrs	62
47	The Gardener Eng School	Kailali	MSc	14 yrs	56
48	Springdale Eng School	Bhaktapur	MSc	6 yrs	34
48	Gundu Eng School	Bhaktapur	BSc, BEd	6 yrs	76
49	Siru Shining Eng Shool	Bhaktapur	BSc	4 yrs	65
50	Mount Senai Sec. School	Bhaktapur	MSc	8 yrs	60
51	Mount Everest Eng. School	Bhaktapur	MSc	5 yrs	76
52	Golden Gate Eng. School	Bhaktapur	BSc	2 yrs	77
53	Wise Land Sec. School	Bhaktapur	BSc	3 yrs	67
54	Tri Star English School	Bhaktapur	BSc	9 yrs	66
55	Mount View Eng. School	Bhaktapur	BSc	13 yrs	63
56	Jana Chetana Eng School	Bhaktapur	Bed	6yrs	60
57	East Point Academy	Bhaktapur	MSc	3 yrs	76
58	Sunshine Sec. School	Bhaktapur	MSc	4 yrs	77
59	Siddhartha Vidyapeeth	Bhaktapur	BSc	6 yrs	67
60	Puja English Sec School	Bhaktapur	BSc	10 yrs	66
61	Bhaktapur Eng. School	Bhaktapur	MSc	11 yrs	63
62	Om Gyan Mandir Sec School	Bhaktapur	MSc	14 yrs	76
63	Gems HS School	Lalitpur	BSc	6 yrs	74
64	Little Angel's School	Lalitpur	BSc	6 yrs	45
65	Angel's Heart Sec School	Lalitpur	BSc	4 yrs	56
66	Baldeekshya Sadan Sec School	Lalitpur	BSc	8 yrs	57
67	Hill Top Eng School	Lalitpur	Bed	5 yrs	68
68	The Rising School	Lalitpur	MSc	2 yrs	54

69	Children's Paradise	Lalitpur	MSc	3 yrs	54
70	Global High School	Lalitpur	BSc	9 yrs	65
71	Lali Gurans Sec. School	Lalitpur	BSc	13 yrs	76
72	Moon Light Sec School	Lalitpur	MSc	6yrs	45
73	Ideal Model Eng. School	Lalitpur	MSc	3 yrs	57
74	Children's Heaven School	Lalitpur	BSc	4 yrs	46
75	Gyankunj Sec. School	Lalitpur	BSc	6 yrs	56
76	Valley Public Eng School	Lalitpur	BSc	10 yrs	76
77	Universal B. School	Nuwakot	BSc	11 yrs	67
78	Nava Jeevan Eng School	Nuwakot	Bed	14 yrs	62
79	Uttar Gaya Eng. School	Nuwakot	MSc	6 yrs	56
80	Pioneer Eng Sec School	Nuwakot	MSc	6 yrs	34
81	Gyan Jyoti Eng School	Nuwakot	BSc	10 yrs	76
82	Amar Jyoti Sec School	Nuwakot	BSc	11 yrs	45
83	Chhetra pal Sec School	Nuwakot	MSc	14 yrs	57
84	Kundala Sec School	Nuwakot	MSc	6 yrs	46
85	Mahendra Eng. Sec School	Nuwakot	BSc	14 yrs	56